THE MERRIMACK:

DESIGNS FOR A CLEAN RIVER

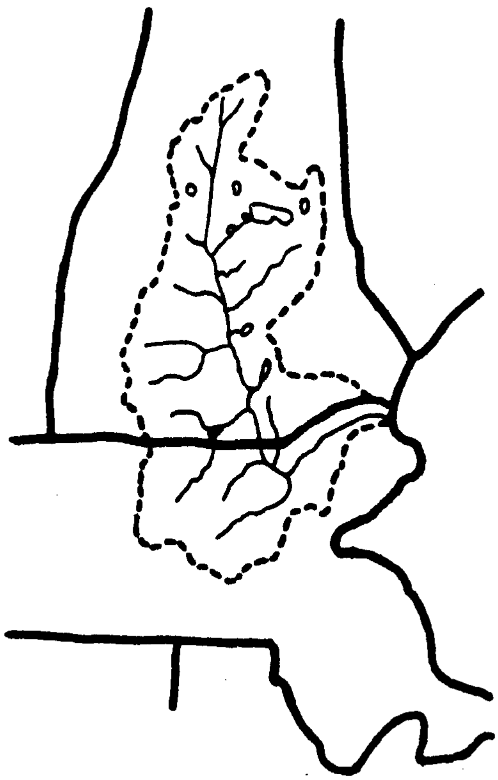
ASSESSMENT AND EVALUATION OF SELECTED ALTERNATIVES

APPENDIX IV & V

AUGUST 1971

THE MERRIMACK:

DESIGNS FOR A CLEAN RIVER



ASSESSMENT OF IMPACTS OF SELECTED ALTERNATIVES

APPENDIX IV

AUGUST 1971

THE MERRIMACK: DESIGNS FOR A CLEAN RIVER

A

FEASIBILITY STUDY

FOR

WASTEWATER MANAGEMENT

IN THE

MERRIMACK RIVER BASIN

APPENDIX IV

ASSESSMENT OF IMPACTS OF SELECTED ALTERNATIVES

TABLE OF CONTENTS

APPENDIX IV

	Page
CHAPTER A. INTRODUCTION	IV-A-1
1. ECOLOGIC ASSUMPTIONS AND CRITERIA	IV-A-3
2. HYGIENIC ASSUMPTIONS AND CRITERIA	IV-A-8
3. AESTHETIC ASSUMPTIONS AND CRITERIA	IV-A-12
4. SOCIAL OPPORTUNITY ASSUMPTIONS AND CRITERIA	IV-A-27
5. ECONOMIC ASSUMPTIONS AND CRITERIA	IV-A-29
CHAPTER B. BASELINE INFORMATION	
1. ECOLOGY	
a. The Land	IV-B-1
b. The Rivers	IV-B-4
c. The Merrimack Estuary	IV-B-10
2. HYGIENE	IV-B-25
3. AESTHETICS	
a. Visual Attitudes and Response	IV-B-36
b. Potentials for Aesthetic Impact	IV-B-36
c. The Merrimack Landscape	IV-B-42
d. The Merrimack Riverscape	IV-B-46
e. Baseline Conclusions	IV-B-47
4. SOCIAL OPPORTUNITIES	
a. Land Use	IV-B-49
b. Population	IV-B-49

		Page
	c. Leisure Opportunities	IV-B-50
	d. Municipal Services	IV-B-51
	e. Institutional Involvement	IV-B-51
	f. Community Image	IV-B-52
5.	ECONOMICS	
	a. General Economic Profile	IV-B-53
	b. Agriculture	IV-B-57
	c. Projections for Agriculture	IV-B-61
	d. Manufacturing	IV-B-62
	e. Service and Population Related Industries	IV-B-68
	f. Recreation and Tourism	IV-B-69
	g. Fish and Wildlife	IV-B-71
	h. Visual and Cultural Environment	IV-B-74

CHAPTER C. IMPACT OF SOLUTIONS

1.	CURRENT EPA-STATE WASTEWATER TREATMENT PROGRAM	
	a. Ecologic	IV-C-1
	b. Hygienic	IV-C-2
	c. Aesthetics	IV-C-3
	d. Social Opportunities	IV-C-4
	e. Economics	IV-C-7
2.	SCHEME #1 - DECENTRALIZED WATER ORIENTED SYSTEM	
	a. Ecologic	IV-C-9
	b. Hygienic	IV-C-12
	c. Aesthetics	IV-C-14
	d. Social Opportunities	IV-C-15
	e. Economics	IV-C-19
3.	SCHEME #2 - PARTIALLY DECENTRALIZED WATER ORIENTED SYSTEM	
	a. Ecologic	IV-C-24
	b. Hygienic	IV-C-26
	c. Aesthetics	IV-C-26

	Page
d. Social Opportunities	IV-C-27
e. Economics	IV-C-28
4. SCHEME #3 - CENTRALIZED WATER ORIENTED SYSTEM	
a. Ecologic	IV-C-30
b. Hygienic	IV-C-33
c. Aesthetics	IV-C-33
d. Social Opportunities	IV-C-34
e. Economics	IV-C-35
5. SCHEME #4 - DECENTRALIZED LAND ORIENTED SYSTEM	
a. Ecologic	IV-C-38
b. Hygienic	IV-C-45
c. Aesthetics	IV-C-47
d. Social Opportunities	IV-C-49
e. Economics	IV-C-56
6. SCHEME #5 - DECENTRALIZED WATER AND LAND ORIENTED SYSTEM	
a. Ecologic	IV-C-67
b. Hygienic	IV-C-69
c. Aesthetics	IV-C-71
d. Social Opportunities	IV-C-71
e. Economics	IV-C-73
7. SCHEME #6 - DECENTRALIZED-ALTERNATING WATER AND LAND ORIENTED SYSTEM	
a. Ecologic	IV-C-74
b. Hygienic	IV-C-76
c. Aesthetics	IV-C-76
d. Social Opportunities	IV-C-76
e. Economics	IV-C-77
8. SCHEME #7 - CENTRALIZED-ALTERNATING WATER AND LAND ORIENTED SYSTEM	
a. Ecologic	IV-C-79
b. Hygienic	IV-C-81

	Page
c. Aesthetics	IV-C-81
d. Social Opportunities	IV-C-82
e. Economics	IV-C-83

CHAPTER D. RESEARCH NEEDS

1. ECOLOGY	IV-D-1
2. HYGIENE	IV-D-2
3. AESTHETICS	IV-D-2
4. SOCIAL OPPORTUNITIES	IV-D-3
5. ECONOMICS	IV-D-3

LIST OF TABLES

TABLE NO.	TITLE	PAGE
A1	Most Frequent *Salmonella* Insolation, 1964	A-11
A2	Social Impact Measurement	A-28
B1	Soil Associations in Merrimack River Basin	B-6
B2	Nutrient Content of Water Samples Taken at Various Locations on June 27, 1971	B-17
B3	Fish of the Merrimack Estuary	B-19
B4	Plant Species of the Merrimack Estuary of Flora Collected and Identified by Jerome, Ghesmore, Anderson, and Guice.	B-21
B5	Numbers and Feeding Characteristics of Waterfowl Species Frequenting the Merrimack River Estuary during the Fall and Winter	B-23
B6	Bacteria on Vegetables	B-30
B7	*Salmonella* Species Recovered in the Merrimack River Basin	B-31
B8	Salient Statistics of the Merrimack River	B-53
B9	Subregions, Economic Indicators, 1960	B-54
B10	Salient Statistics of Agriculture in Four New Hampshire Counties	B-59
B11	Average Value of Land and Buildings per Farm Acreage, 1964	B-59
B12	Agriculture Production in Four New Hampshire Counties, 1964	B-60
B13	Statistics Concerning Manufacturing Establishments with over 20 Employees 1963	B-64
B-14	Population, Personnel Income and Earnings Projected for Selected Years, 1970 - 2020	B-65
B-15	Population, Personal Income, Earnings and Employment Historical and Projected for Selected Years	B-66

LIST OF FIGURES

FIGURE	TITLE	PAGE
A1	Integration of Sewage Treatment Plant into the Urban Environment	A-17
A2	An Underground Tank (Settling, Coagulation or Filtering) in an urban Area - Sports Stadium Above	A-19
A3	Integration of Transport Lines and Recreation Corridors	A-20
A4	Flow Augmentation Outfall	A-21
A5	Aeration Lagoon	A-22
A6	Settling Lagoons	A-22
A7	Storage Lagoons	A-23
A8	Spray Irrigation Overland Flow	A-23
A9	Spray Irrigation Infiltration	A-24
B1	Dissolved Oxygen in Merrimack River	B-11
B2	Coliform Bacteria in the New Hampshire Section of the Merrimack River 1965	B-26
B3	Coliform Bacteria in Massachusetts Section of the Merrimack River, 1964	B-27
B4	Total Coliforms in Merrimack River Estuary-High Tide	B-34
B5	Total Coliforms in Merrimack River Estuary-Low Tide	B-35
B6	The Unappreciated River	B-37
B7	Industrial Discoloration	B-40
B8	Water Surface Degradation	B-40
B9	The Upper Merrimack Basin	B-43
B10	The Lower Merrimack Basin	B-45

LIST OF PLATES

Plate	Title	Page
1	Merrimack River Basin Map Soil Associations	B-5
2	Stream Classification of the Merrimack River Basin	B-9
3.	Portion of the Merrimack Estuary from USC & GS Chart No. 213	B-12
4	Cities and Towns in Study Areas	B-55

CHAPTER A. INTRODUCTION

A wastewater management study may contribute to the objectives of a broad water management program through the development of alternatives which improve the water quality of the region as well as the total environment. Once various programs have been developed, these alternative water management strategies must be assessed and evaluated in terms of specific contributions to the overall objectives.

In an immediate sense, the objectives of the Wastewater Management Program for the Merrimack River Basin are to improve the water quality in the Merrimack River and its tributaries. However, broader objectives relating to water quality, wastewater management, total water management, and total resource management concern environmental quality, the social well-being of the area, and national and regional development.

The measurement of contribution of the overall objectives must be set forth in terms of the characteristics of the Basin. For purposes of this Feasibility Study for wastewater management, the Merrimack River Basin will be described in terms of its ecologic, hygienic, aesthetic, social opportunity and economic characteristics.

Each characteristic associated with the use of the environmental resources of the Merrimack River Basin has its own criteria and assumptions which must be laid out before an assessment of the various impacts can be made. The criteria and assumptions used in the assessment of the various impacts are set forth in the following discussions.

Once the criteria and assumptions are laid out, the current environmental situation or baseline of the Merrimack River Basin can be set forth. The baseline will be presented in terms of the above characteristics for purposes of orderly discussion.

Once the baseline of the Merrimack River Basin has been established, the changes or impacts to that situation that any wastewater management scheme cause can be assessed in terms of the ecologic, hygienic, aesthetic, social opportunity and economic characteristics.

1. ECOLOGIC ASSUMPTIONS AND CRITERIA

Assessing the ecological impact of alternative watewater management schemes requires that certain criteria and assumptions be laid out. These can be expressed by the general catagories of energy flow, nutrient cycles, the substrate and the growing media, bioclimatic responses, and the hydro-logic cycle.

The concept of energy flow is basic to any ecosystem. The principle forms of energy impinging upon any ecosystem are: radiation from the sun, geologic forces and the potential energy of gravity. These, in combination with the presence of water with its high latent heat, produce general and localized atmospheric conditions. The biota within any particular ecosystem exist at the interface of these energy inputs in response to the proportions of solar, geologic, gravitational and atmospheric engeries input at any particular time and place.

The concept of cyclic systems is very important to the understanding of the maintenance of ecological performance on a continuing basis. Cycling is accomplished by the system building mechanisms, which retain essential building blocks within the system, cycling them from primary producers, to consumers and then to decomposers, who return the building blocks to the air, water and soil. The building blocks are the basic plant nutrients (i. e. nitrogen, phosphorus, potassium, calcium, and iron), oxygen, carbon dioxide, and water. The relatively closed nutrient and gas cycles are accomplished through feedback mechanisms arranged among and within the structural layers of natural communities. In a sense, each structural layer of a natural community is a broad habitat supporting its own respective populations of producer, consumer and decomposer organisms.

All living things require a basic substrate for anchorage, a supply of nutrients, and a growth medium. Terrestrial organisms have the soil as the essential substrate and air is their growth medium. In the case of many aquatic organisms, water may be both the substrate and the medium, through for rooted aquatic plants and sessile aquatic animals the river or stream bottom may be the substrate.

Within the substrate and the medium there is a general need for continuity of chemical quality and quantity through any annual cycle of natural growth and reproduction. This continuity does not mean a constant amount or proportional arrangement of chemical substances within the substrate or media each day of the year, but rather a pattern of chemical conditions which is more or less repeated season after season, year after year.

There is also a need to maintain continuity of physical conditions on the same basis as chemcial quality and quantity. It is the pattern of temperature changes and energy inputs into the environmental that constitutes the physical parameters within which speciation has occurred, successsion has taken place, and the adaptive amplitude of any individual within the community was determined.

Because the surface of the earth, the atmosphere, and the amount of short-wave radiation reaching the surface to the earth are never constant through long periods of time, it can be said that all living systems exist under a state of environmental stress.

The environmental stresses within the living system may be both long-term and/or short term, i.e., geologic and climatic changes. The longrun geologic changes tend to be related to the basic geological concepts of tectonics and erosion. In the short-run, some geologic phenomena tend to be localized in extent or instantaneous in time, i.e., there can be local earth movements such as earthquakes, land flows or surface erosion. Their effects are usually brief and do not alter the basic distribution or structural arrangement of the biota, except on the site effected.

Climatic changes are related to patterns of atmospheric phenomena which produce hot or cold and wet or dry environmental conditions, which are expressed seasonally and diurnally. These conditions are due in part to the short-wave radiation acting on the surface of the earth with subsequent entropic breakdown to long-wave radiation. Sufficient energy is imparted to the land, sea, and atmosphere water by the long-wave radiation to produce seasonal and diurnal climatic conditions.

Aberrations in the climate may produce localized stress such as low probability precipitation patterns and early and late frost. These stresses may be significant within the area affected in that they may change the pattern of succession and structural arrangement of the biotic community.

An important climatic component affecting any area is the hydrologic cycle. In general, the hydrologic cycle consists of evaporation of water from the earth's surface, movement of this water as water vapor through the atmosphere, condensation of the water vapor and precipitation of the water back to the earth's surface as rain, snow, hail, and etc. Evapotranspiration returns from 50 - 97% of the precipitation back into the atmosphere while 2-27% finds its way directly to streams, lakes, and ponds, and the remaining 1-20% infiltrates into the ground.

During short and long periods of time biotic succession is important. By this process an area of land or water is successively invaded and populated by a series of plants and animals, increasing the biotic diversity and complexity of the community. As the community approaches the latter stages of succession, the annual quantity of primary production (the organic material produced by photosynethizing plants) is equalled by the annual respiration of all organisms utilizing the system. Thus, in a more mature community the ratio of annual primary production to annual respiration (P/R) approaches one with very little amplitude of changes through time. Thus, a community having a P/R ratio is approaching one, may be considered a stable community.

An ecosystem resembles a "cybernetic system" - that is, self-creative, self-repairing, and self-adjusting. Basically the self-creative function is related to genetic evolution and the capacity to develop new living forms and functional diversities through long periods of time in response to the more profound, long-run stress factors. The self-repairing capacity is expressed as the series of successional stages leading to a more stable, mature system. The self-adjusting capacity is related to the adaptive amplitude of each of each organism to endure patterns of diurnal, seasonal, and annual changes

The most frequent change which human activities exert upon the stress patterns within an ecosystem is the alteration of the sequence of events and/or substances as they occur through time. These changes are exemplified by the following activities:

1. Removal of organic and inorganic material faster than growth or import systems can replace these materials.

2. An import of organic and inorganic substances and energy to a place faster than assimilation and growth systems can adjust to the imported factors.
3. Alternation of the water regimen on the land and to a lesser extent in the atmosphere.
4. Development and introduction of substances or energy, either in kind or intensity, which exceed the tolerance limits of the genetic stock making up the ecosystem.
5. Acceleration or retardation of geologic processes, especially erosion.

Human activity could alter a biological system's cybernetic capacity through any of the following occurrences:

1. The extinction of a species.
2. The alteration of the structure of natural communities. For example, removing or degrading the life form layers of a community, thus reducing the spectrum of habitats and causing a loss of dependent macrobiotic and microbiotic flora and fauna.
3. Creating stresses which cause individual organisms to exist beyond either extreme of their adaptive capacity.

2. HYGIENIC ASSUMPTIONS AND CRITERIA

Hygienic impacts are generated by the nature of the direct and indirect changes in the utility of resources associated with the physical and biochemical characteristics of each wastewater management scheme. The effect of alternatives schemes on toxicants and pathogens can be expected to exhibit the greatest hygienic impact. Hence, significant hygienic impacts, may be expected as a consequence of toxicants and pathogens affecting urban-oriented food and fibers, production and recreational activities in which the toxic agents or disease vectors are most likely to be ingested or come in contact with the public.

In the impacts assessment of the Merrimack River Basin Wastewater Management Program the areas of greatest concern are recreational use of water bodies, i.e., the Merrimack River, food and fiber reproduction using wastewater irrigation, and the harvesting of food from the water bodies within the Merrimack River Basin.

Coliform bacteria have been used an an indicator and criteria of the hygienic characteristic of water. Incidence levels of these organisms have been established for various uses of water. The presense of these organisms indicate the possible presence of other more harmful pathogens. However, only the detection of pathogenic Salmonella bacteria or any other organism is proof that other organisms are present.

Salmonellosis, the diseases caused by various species of Salmonella bacteria, of which there are more than 900 known serological types, includes typhoid fever, gastroenteritis and diarrhea. During 1964, there were over 21,000 <u>Salmonella</u> isolations from humans in the United States and 57 known deaths resulting from Salmonellosis. Table Al lists the ten most common Salmonella serotypes, clinical disease cases and carriers in the United States during 1964.[1]

In general the disease associated with water contact are those of the eye, ear, nose, throat, gastrointestinal tract, and skin. Additional diseases associated with skin (or other) contact with water contaminated with microorganisms in the continental U.S. includes: achistosome dermatitis, leptospirosis, tularemia, some tuberculous skin infections, and amoebic meningencephalitis. However, the number of known cases of these diseases resulting from water contact is small.

Viral hepatitis may be transmitted by contaminated water, contaminated shellfish or other food or drink, person-to-person contact, and through the air. Viral hepatitis is probably the most frequently transmitted fecal-oral disease. Special mention is made of hepatitis for two reasons: First, techniques have not yet been developed to culture and study this virus in the laboratory and second, available epidemiologic data indicate that hepatitis viruses are unusually resistant to water treatment processes. There have been a number of outbreaks of viral hepatitis associated with contaminated drinking water and some with chlorinated drinking water. Thus, the hazard of hepatitis associated with ingesting untreated contaminated water during recreational activities such as swimming could be significant.

1./ <u>Salmonella</u> Surveillance Report, Annual Summery - 1964, Communicable Disease Center, U.S. Department of Health, Education, and Welfare Atlanta, Georgia.

Shellfish harvested from polluted areas are capable of causing human disease, including typhoid fever, various enteric infections, and viral hepatitis. However, if standards developed for shellfish sanitation including strict enforcement of prohibitive shellfish harvesting from areas known to be polluted are followed, the hazards of infection from shellfish are minimal. Other shellfish or finfish disease, i.e., Diphyllobothriasis, be acquired by eating either inadequately cooked, infected fish or uncontaminated fish or shellfish which have become contaminated with various microorganisms after harvesting.

In summary, the large number of water related diseases which result from water contact in the U.S. include: infectious hepatitis; giardiasis, typhoid and paratyphoid fevers; salmonellosis; shigellosis; leptospirosis; amebiasis; "gastroenteritis" of unknown etiology due to microbial contamination, including viral contamination; echinococcosis; balantideasis; schistosome dermatitis; tuberculous skin infections; and emoebic meningoencephalitis.

The dose of microbial (or parasitic) contamination, the virulence of pathogenicity of the organisms, the immune status (and other host characteristics) of those exposed, and other factors may influence the amount of infection and disease that results from human exposure to the contaminating organisms.

This study will outline some of the areas of concern related to diseases and toxicants which are reflected in the various wastewater management schemes. What is presented in the following section is by no means a complete examination of the hygienic characteristic of the Merrimack River Basin, but is rather an outline of the significant areas.

TABLE A1

MOST FREQUENT SALMONELLA ISOLATION, 1964 1/

SEROTYPE	NUMBER OF CASES	PERCENT OF TOTAL	FOUND IN MERRIMACK RIVER BASIN
S. typhimurium & S. typhimurium v. cop.	5,862	27.8	Yes
S. derby	2,360	11.2	Yes
S. heidelberg	1,717	8.1	Yes
S. infantis	1,523	7.2	Yes
S. newport	1,036	4.9	Yes
S. enteritidis	801	3.8	Yes
S. typhi	703	3.3	No
S. saint-paul	645	3.1	Yes
S. oranienburg	550	2.6	Yes
S. montevideo	524	2.5	Yes
TOTAL	15,721	74.5	
TOTAL (all serotypes)	21,113	100.0	

1/ Op. cit.

3. AESTHETIC ASSUMPTIONS AND CRITERIA

The need for comprehensible terms defining aesthetic impacts becomes particularly obvious when broad or intangible topics such as visual, auditory, olfactory, and taste senses are considered. "Aesthetic impacts" is the term chosen for discerning if a physical feature or environment affects you positively or negatively and to some extent how strongly it affects you (dramatically, moderately, or insignificantly) and its direction (positive or negative). Tied directly to aesthetic impacts are cultural uses which in this study are simply uses of different land and water areas which have some visual consequence.

As with any land using activity (wastewater management facilities) aesthetic and cultural costs and benefits accrue from the landscape consumed and are dependent upon two components:

1. The scale and design quality of the facility.
2. The physical components and quality of the landscape.

The more concentrated and developed (structured) the system (wastewater management processes) the more the design of the facility becomes primary to the visual impact. The processes that are less structured and less technical (land disposal) utilize more land; however, there is a greater potential for landscape qualities to be strongly determinant upon resultant visual impact.

When discussing aesthetic and cultural impacts it is convenient to discuss them as primary and secondary impacts. The primary impact of advanced wastewater technology is the cleanliness and utility of the river established through the removal of pollutants at the treatment plant. Secondary impacts relate to items such as the effect that the structure, i.e. the treatment plant, is able to exert on the surrounding landscape. Additional secondary effects might be the greater control of urban expansion using transmission lines and irrigation sites as devices for structuring urban growth into a comprehensible form once land use capabilities and policy decisions are determined. Secondary impacts related to the architectural design of the facility, and plant location, as it affects sewage transmission routes, may well achieve the same scale of importance as the primary impact of clean water in the river. The directed growth of an entire region, the attendant suburbanization or urbanization, and industrial expansion can affect large land areas and may be visually more dramatic than the water treatment facilities. It is therefore desirable to closely examine these secondary impacts when considering the overall merits of a particular wastewater management scheme.

The following points are the major guiding criteria to ascertain aesthetic impacts in the Merrimack Basin:

1. Primary impact - The visual appearance of the river; the actual quality of the water, and resultant change in its direct use.
2. Scale - The amount of area and the population directly affected by water improvement.
3. Location - Whether the system is responsive to variation and uniqueness in the existing landscapes.

4. Planning opportunities - The planning opportunities and constraints inherent in the system with particular reference to multiple use, potential large scale land use control, and becoming active parts of the community.
5. Direction of the impact - Whether the impact is generally negative or positive in its visual, sensory or land use impacts.
6. Flexibility - The flexibility of the system in terms of location, size, physical composition, and land relation to existing waste treatment facilities.

The Deep Aesthetic

People can make a great many primary sensory decisions as to whether a body of water is of clean quality, but the strong judgments on the aesthetic quality of a water body arise from past associations, both conscious and subconscious. As man has changed the use of the river from a partner in man's survival to a servant for the disposal of wastes, he has concurrently changed his deep aesthetic notions of rivers.

An example of the deep aesthetic attitude is aptly employed by the advertising media. Mountain streams successfully draw strong associations of cool and delicious water splashing and tumbling over and through rocks in a completely natural setting. The crystal clear mountain stream does not include the association of man-made structures impinging upon shoreline or interfering with flow.

Mass media has psychologically induced people to use mountain stream characteristics as a base line for judgment on the aesthetic quality of river courses. Therefore, people's aesthetic association with the Merrimack River precludes their ability to completely obtain the mountain stream stereotype. Thus not only must our technology change the physical barriers to use of the river, but it must also change the mental barriers to use of the river.

Design Variables

The aesthetic impact assessment of the Merrimack land and riverscape is based upon two factors, past planning and design experience, and related visual testing. A discussion of these factors requires that some major variables that are strongly suspect and that have been proven to influence visual quality and preference be identified first. The following randomly ordered statements identify and describe these variables as they relate to the Merrimack Basin.

Visible Water - It has been proven that people consistently prefer landscapes with water over those without water. Thus the Merrimack is visually important.

Variety of Natural Landscape Components - People enjoy a changing landscape, i.e. from forest to pasture to cropland.

Topographic Change - One would rather view a rolling, mountainous scene than a flatlands scene.

A Repetitive Theme within the Variety of Elements - Variety and diversity can create a sensory overload (confusion) but a repetitive theme, i.e. the river, is a reorientation factor.

Some Open Land - People prefer landscapes with some open land. The Merrimack has minimal quantities of open land which are generally located near the River itself.

Sharp Contrasts especially on Land/Water Edge - Rugged sharp edges are preferred over those that are smooth and softened by vegetation. Edges make the landscape structure more visible and comprehendable.

Irregular Edge Configuration and Curvilinear Alignment - A smooth regular shoreline that can be easily observed at one glance has less visual impact than an irregular shoreline that reveals itself segmentally as one drives or walks along it.

Variation from Full Spatial Enclosure to no Spatial Enclosure - Along the Merrimack River there are few examples of full spatial enclosure. The quality of the River may be increased in specific locations through construction of buildings to achieve full enclosure.

Varied Viewing Height and Distance - A change in visual access increases landscape preference through variety and uniformity. The Merrimack offers minimal viewer variation.

Good Physical/Visual Access - To facilitate the views and attributes just mentioned, it is necessary to introduce planned visual and physical access.

Any program that will contribute to the enhancement of the above variables will increase the aesthetic quality of the Basin.

<u>System Components</u>

There are basically five wastewater management system components which will interact with the visual landscape. The components may generate a negative or positive impact of varying degrees depending upon the context of the landscape into which they are introduced. (Figure A1).

Figure A1

VISUAL INTERACTION

LANDSCAPE COMPONENTS / SYSTEM COMPONENTS	OPEN LAND	VEGETATED LAND	TOPOGRAPHIC CHANGE	POPULATION DISTRI-BUTION	WATER BODIES & WET LANDS	DISTANCE FROM RIVER
A ST PLANTS	STRONG	MOD.	STRONG	SLIGHT	SLIGHT	SLIGHT
B TRANSPORT LINES	MOD.	STRONG	STRONG	MOD.	SLIGHT	SLIGHT
C STORAGE LAGOONS	SLIGHT	MOD.	STRONG	MOD.	MOD.	SLIGHT
D OVERLAND FLOW	SLIGHT	STRONG	STRONG	SLIGHT	MOD.	SLIGHT
E IRRIGATION FIELDS	STRONG	STRONG	STRONG	SLIGHT	SLIGHT	SLIGHT

STRONG MOD. SLIGHT

Sewage Treatment Plants

Treatment plants when placed in existing open land are potentially visible from a larger area. This visibility could produce a negative or positive impact on large numbers of people, dependent upon design considerations. If located in large open areas an attempt should be made to locate it adjacent to the edge of such a space and begin to integrate it with the edge structures, topography or vegetation contained in the open land.

Sewage treatment plants are intolerant of large (20 ft.) topographic change and thus would be located on relatively level lands most often in the river valleys or its plateau land. As topography is generally steeper in the northern part of the basin it can be expected to be more difficult to effectively locate many large facilities there. Since the plants are of the same design vernacular and of the same materials as other of man's structures, their development in densely populated urban areas should not be precluded. A sensitive and responsive design to adjacent land uses and urban needs could be developed within an urban context. Ideally, such a design would generate community involvement of both a passive and active nature. This could be achieved through multiple use of land using the potential of clean water in an urban park over component systems. Design of such a facility would require the organization of an interdisciplinary design team at the pre-planning stage of project development (Figure A2).

Sewage treatment plants need not be located directly adjacent to the rivers. In the Merrimack Basin there are few such non-floodable

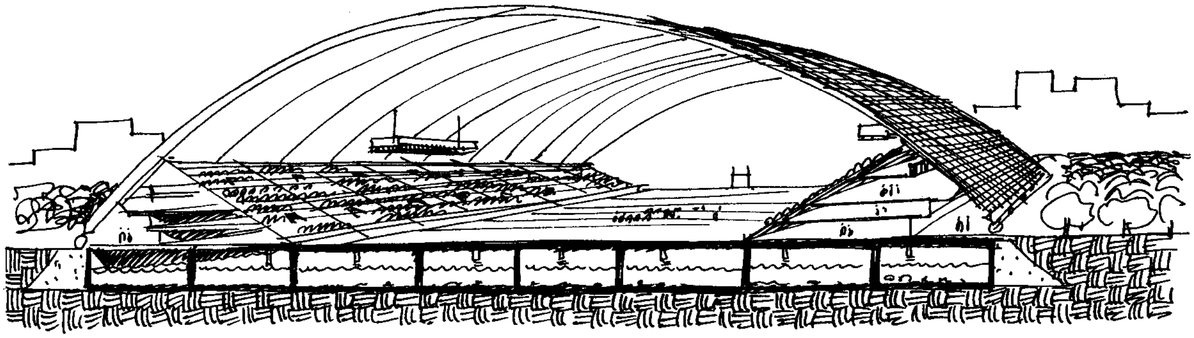


Figure A2. An Underground Tank (Settling, Coagulation, Filtering) in an urban area - sports stadium above

sites available for any type of development. Should multiple use or competitive use be considered it may be more desirable to move the plants away from the River edge and thus make such a location available for an alternative use.

Wetlands and water bodies are inappropriate in most cases as locations for sewage treatment plants. The edge of a lake, however, may be necessary for such a facility. In the Merrimack Basin, with its paucity of water bodies and land water edge, this should however, be avoided if at all possible.

Transport Lines

Since open land in the Merrimack Basin is most often the flat river valley lands that are fertile and remain viable for agriculture, transport lines that are below ground in thses areas will have little effect upon the landscape. If, however, thses lines were surface structures, there would be considerable visual and physical disruption to one of the key visual resources of the Basin.

Transport lines traversing forested areas and areas of topographic change have significant effects upon the surface vegetation and form.

This can be a visual advantage to opening up visual and physical access to the landscape if a varying width of vegetative clearing is used rather than straight cut line clearing practices. These transport systems can also be combined with highway, railroad, and power transmission lines to mitigate some of the negative visual impact.

Transport lines should be subsurface rather than surface if at all possible. They should not restrict physical or visual access to the River itself as the railroad and its embankment so often does presently. Care should be taken to route the transport lines so they conform to the contours of the land and not cut straight across the countours in an unnatural zig-zag pattern. The introduction of this line along the River edge, however, provides an opportunity for selective vegetative clearing to open up visual access to the River, which is so desperately needed throughout much of the River's length. Urban areas within the Basin are in need of additional open space. It would seem possible that a system of linear paths connecting playgrounds, mini parks, neighborhoods, schools and shopping facilities could be integrated

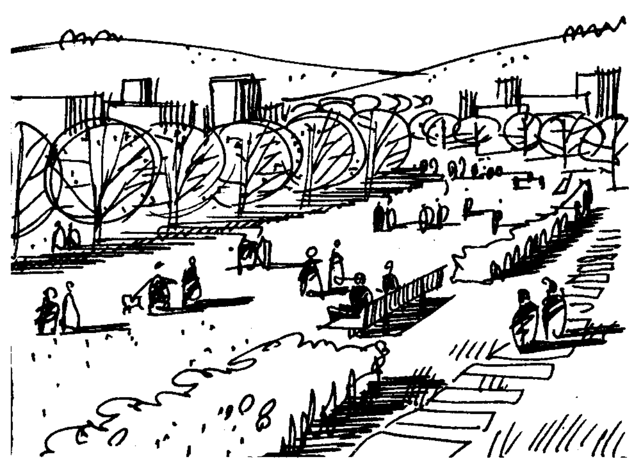


Fig. A3 Integration of Transport Lines and Recreational Corridors with transmission line rights-of-way (Figure A3). With further expansion, such a system could develop into recreational corridors for horse=back riding, bicycling, hiking and snowmobiling in rural areas.

The point discharge of transport facilities into lakes or rivers needs careful design attention. The land/water edge is an extremely visible and fragile portion of the landscape. In urban areas where abundant supplies of clean water are scarce the potential exists to incorporate the discharge point for renovated water into a vibrant water sculpture, fountain, pool, etc., in a waterfront setting(A4)

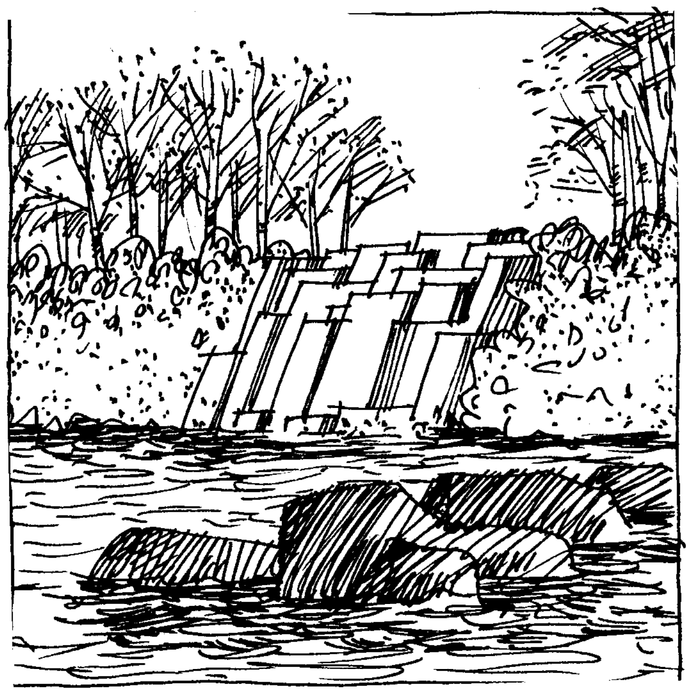


Figure A4. Flow Augmentation Outfall

In less developed areas discharge points could be integrated with stream flow by under water introduction to reduce disruption of the natural condition. Here also is the opportunity for creating new recreational water bodies in areas in need of open space for walking, hiking, boating, fishing and swimming.

Lagoon Systems

Lagoon systems are likely to be more visually beneficial to the large scale landscape if they are located in wooded rather than open land landscapes. The size and nature of these lagoons should preclude short distance viewing and emphasize long distance viewing where these lagoons are a contrast to the landscape pattern (Figure A5).

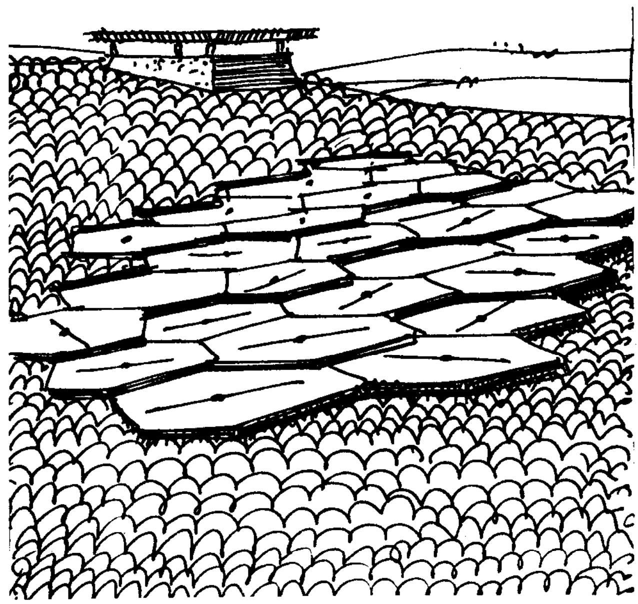


Figure A5. Aeration Lagoons

Lagoons should be located in less densely populated areas and thus would be more appropriate in the northern rather than the southern basin. The corridor along the River contains most of the people and urban development, the transport routes, the most open land, etc. These conditions suggest that lagoons be located at

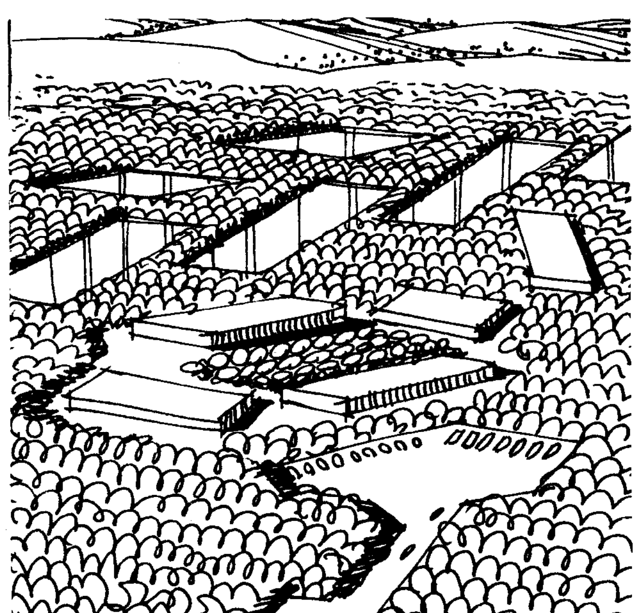


Figure A6. Settling Lagoons

considerable distances (hundreds of yards) from the River, especially in the southern Basin. This will mitigate the visually contrasting and disruptive capacities (Figure A6).

Storage lagoons, because of their size, will have the greatest visual impact. However, they are more adaptable to topographic change as they can be integrated with the natural contours. Aeration and settling lagoons require a geometric form and even though smaller in size will have disrupting consequences in the landscape (Figure A7).

Figure A7. Storage Lagoons

Spray Irrigation - Overland Flow

Overland flow will have a minimal negative visual effect upon steep open land, forested land, and topographical change. It is visually complementary in vegetated areas and is slightly complementary in open lands when the irrigation is operating. (Figure A8)

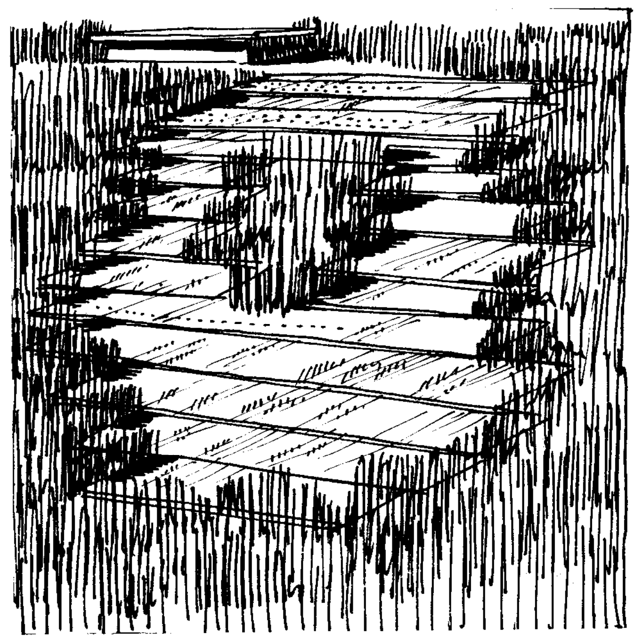


Figure A8. Spray Irrigation Overland Flow

Overland flow is best located in low population areas which exist both in the upper and lower basins.

Spray Irrigation - Infiltration

Irrigation fields are used in open lands and are visually stimulating because of the transient effects of light and wind on moving water. This view is especially stimulating from a high viewer dominant position looking down on the open land irrigation and discerning its pattern. Thus irrigation on flat land adjacent to accessible, steeper topographic conditions is a positive condition and does exist at many points along the River (Figure A9).

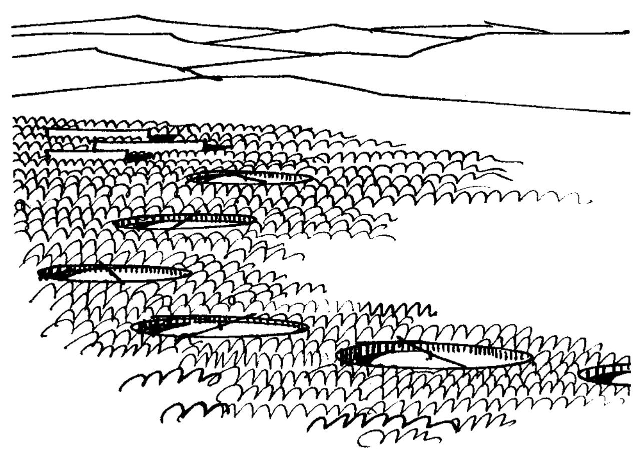


Figure A9. Spray Irrigation Infiltration

Should vegetation be cleared from existing forested lands for irrigation purposes, the tremendous visual advantage of open land would be achieved. Stands of existing windbreaks should be preserved and new windbreaks planted to help micro-climate control of aerosol particles. In addition, they may be used for screening or framing views.

Planning and Design Potential

A clear statement of the development incentive produced by accessible effluent transmission lines should be made. The giving and holding of such services and their exact locations have been and will continue to be key issues as to the development of an area. A policy decision on where and how much development an area should have would be useful for transmission line location. It is quite obvious that a management scheme that gives equal access to all areas of the Basin by connecting transmission lines loses the control it has by carefully placing smaller quantities of those lines. A scheme with 25 miles of transmission lines may provide more control on urban growth than a scheme with 250 miles of such lines.

The following statements are intended to suggest planning and design considerations that would be important to the aesthetic impact of the River:

- Utilize the rivers for their potential to regenerate urban shoreline development.
- Concentrate shoreline development in or near existing cities and towns and emphasize redevelopment first.
- Utilize highway and river intersections, dams, railroad and river intersections, and power transmission lines and river intersections as the points of visual and physical access and recreational and other use developments.
- The addition of weirs and aeration jets in key visible points of the river would add visual excitement and interest and make the river a focus.
- Develop a canoe-boat-camping system along the river.

- Provide all types of physical access including facilities adjacent to the river; parks, parking, sanitary facilities, docks, etc.

- Design towers, high bridges in the southern portion of the river to give identity to the river's location in the larger landscape and to give the added variety of a viewer dominant position.

- Make design and redesign of highways in proximity of the river river respond to the river's alignment thus exerting a visible influence on land use.

- Utilize the railroad land holdings as access in as many ways as possible.

- Integrate sewage treatment plants into existing structured areas rather than adjacent to the river in undeveloped landscapes.

- Locate treated water outfalls in deep, fast moving water to minimize visual impression or maximize the outfall by making into a man-made waterfall sculpture in a park-like setting.

- The most important issue is to induce use into the river through the facilities provided. This will impart a "use meaning" that will lead to emotional, symbolic and visual meanings as their consequence.

- Make use of transmission facilities, and their ability to afford visual access to the river.

- Maximize as much as possible low flow augmentation well distributed along the river's length.

- Place irrigation facilities both near the river and upon distant hillsides, using the open land created as the greatest contributor to pattern interest.

4. SOCIAL OPPORTUNITY ASSUMPTIONS AND CRITERIA

In examining any given wastewater management scheme, it is necessary to measure and evaluate the impact that a scheme has on the social opportunity characteristics of the region. Within the scope of a feasibility study, it is not possible to make absolute statements of fact as to the changes that would take place. Educated forecasts which are made in the following analyses are based on available data and intuitive judgment. To structure this judgment, this analysis uses a three dimensional matrix composed of the following elements:

1. Impact categories, delineating aspects of social activity (Table A2).
2. Sub-regions, geographic area of the Merrimack River Basin large enough to make gross change detectable.
3. Alternative wastewater management schemes.

Using this approach the significant changes in social opportunities within the Merrimack River Basin are identified.

TABLE A2 - SOCIAL IMPACT MEASUREMENT

Impact Category	Suggested Measures	Units	Time Period
1. Land Use	Net change in the percent and distribution of acres devoted to industrial, commercial, residential, recreational and other land uses.	Percent	Long
	Number of feet of incompatible land uses separated by the facility, minus the number of feet of compatible uses separated.	Feet	Short & Long
	Net change in the amount of land available for development	Acres	Long
2. Population	Net changes in the age, income, race and ethnicity percentages and distributions of the local population	Percent	Long
3. Leisure Opportunities	Net change in the extent to which planned recreation space meets American Society of Planning Officials planning standards relating types of space to population characteristics	Percent	Short
4. Municipal Services	Net change in cost of providing water, sewerage, and service	Dollars	Short & Long
	Net change in cost of providing fire protection	Dollars	Short & Long
	Net change in residential insurance rates	Percent	Long
5. Institutional Involvement	Total number of jurisdictions involved in the totality of the construction process for a treatment facility	Number	Short & Long
	Number of enforcement actions brought against non-compliant offenders; municipal, industrial	Number	Short & Long
6. Community Image	Changes in property values along river	Dollars	Short & Long
	Changes in property values adjacent to treatment facility	Dollars	Short & Long
	Number of positive and negative statements about the water related aspects of the community as revealed by a content analysis of local news media	Number	Short & Long

5. ECONOMIC ASSUMPTIONS AND CRITERIA

The economic effect of the various alternative wastewater management schemes is the identified change in economic productivity attributed to the alternatives. For the purposes of this study, it is assumed that the existing economy of the Merrimack River Basin would materialize as though no changes of an unusual and unforeseen nature or magnitude occur. This condition is the "baseline" economy. This projection is in no way to be construed as a goal, an assigned share, or a constraint upon economic activity. It is, instead, to be a reflection of the economy as it has developed historically, projecting the pattern of development into the future, constrained only by trends in aggregate supply and demand. In this way deviations which may be caused by an alternative scheme can be identified.

The problems involved projecting the baseline itself are enormously complex. One factor that must be borne in mind is that existing economic projections do not conform to watershed boundaries but rather to political subdivisions. For this study the subdivisions used are the counties of Grafton, Belknap, Merrimack, and Hillsborough in New Hampshire and the SMSA's (Standard Metropolitan Statistical Areas) of Fitchburg-Leominster, Lowell, and Lawrence-Haverhill in Massachusetts.

Since the economic projections of the baseline are rough, the impact projections are still less precise. At this time there has been no similarly comprehensive water management program attempted in the United States. Thus, there is very little hard experience to guide in the assessment of economic impacts. In short, the error ranges around the estimates are quite broad, and a great deal of further work will be necessary before satisfactory levels of confidence in the forecasts can be reached.

Within the scope of this feasibility, it has not been possible to assign meaningful dollar values to the noted impacts. In the following sections citing economic impacts, the attempt is only to identify where impacts might result and to indicate in general the direction and magnitude of the resulting change. Where it has been possible from existing data, monetary benefits have been delineated. This assessment should not be interpreted to mean that these identified benefits are the only benefits to be derived from the wastewater management strategies, but rather these benefits are the ones which appear to the assessors first, and most readily.

CHAPTER B. BASELINE INFORMATION

1. ECOLOGY

a. The Land

The Merrimack Basin is a rolling dissected plateau, with occasional peaks which dominate the landscape. The topography of the Basin ranges from mountains in the north to rolling hills in the central and southern sections. This can be broken out as:

Mountains	400 square miles
Steep Hills	1,400 square miles
Rolling Hills	3,200 square miles

The bedrock units within the Basin are mostly granitic rocks, gneisses, and schists. The minerals generally common to all include quartz, feldspar, mica, and iron-magnesium minerals. Covering the bedrock is a blanket of glacial till and stratified glacial deposits derived from the bedrock. The glacial deposits are thinnest in the Northern mountains, which are forested with hardwoods and spruce. The Northern area contains some agricultural land on stream flood plains or valley glacial material.

The glacial outwash and morainal materials in the southern Basin are covered by marine sediments laid down when it was inundated following glacial retreat. This section contains most of the important industrial centers, suburban residential areas, and agricultural lands of the Basin. Within the Basin are several hundred lakes and ponds, resulting from glacial modification of the Basin. Meadows, swamps, and bogs occur in the drained basins of drift-dammed lakes.

The sand deposits are commonly quartz and feldspar grains with very little mica and iron-magnesium minerals. Silt is similar to sand except it commonly has more mica. The clay-sized particles in the Basin are mostly quartz with some feldspar, mica, and iron oxides and some clay minerals (hydrous aluminum silicates).

The characteristics of any soil found in the Basin depend on the five major factors of soil formation: (1) the physical and mineral compositions of the parent material, (2) the climate under which the parent material has accumulated and weathered, (3) the plants and animals living in and on the parent material, (4) the topography of the land, and (5) the length of time the climate and living organisms have acted on the parent material.

Most basin soils are grouped as either Podzols or Brown podzolic soils. A typical podzolic soil develops as a result of high leaching in sandstone, usually under coniferous forest. The soil has a low pH (generally less than 5.5) which enhances fungal decomposition of the surface litter rather than bacterial decay. As a consequence of the high leaching rate and acid conditions a light gray horizon (A2 horizon) is formed in the upper soil profile. The iron and aluminum oxides, organic material and clay removed from this horizon are deposited in the lower soil profile (B horizon).

Brown podzolic soils are excessive to moderately well drained soils. Iron and aluminum oxides, clay, and organic matter are leached out of the upper soil profile, moved downward, and precipatated out in in the lower soil profile (B Horizon). The formation of leached zone (A2 Horizon) found in the Podzolic soils is not as striking in the Brown Podzolic soils, because many small animals such as ants, beetles, mice, spiders, etc., intermix the materials in the upper B horizon, A horizon, and the organic surface layer. The Brown Podzolic soil profile is generally acid, has a dark A horizon, and develops under a deciduous-coniferous forest found within the Basin. A clay layer or fragipan which may develop in these soils, greatly reduces downward movement of water.

Soil profiles reflect topographic conditions in addition to the biotic influences and the parent material from which they are derived. In hilly regions, shallow soils generally develop with concomitant high rates of surface run-off and erosion. Flat land areas generally have deeper soils due to little or no surface, plus these areas are subject to deposition of materials carried in surface run-off or in streams.

Horizons in upland and low lying soils, which are periodically waterlogged, due either to perched watertable on an impermeable clay pan or a high watertable, are generally gray-green or gray-blue in color, which is indicative of anaerobic conditions. These soils often have a rusty-brown mottled appearance because of oxidized iron compounds. In low-lying areas where drainage is poor, an accumulation of organic matter which may be only partially decomposed plant material, may form peat on bog soils.

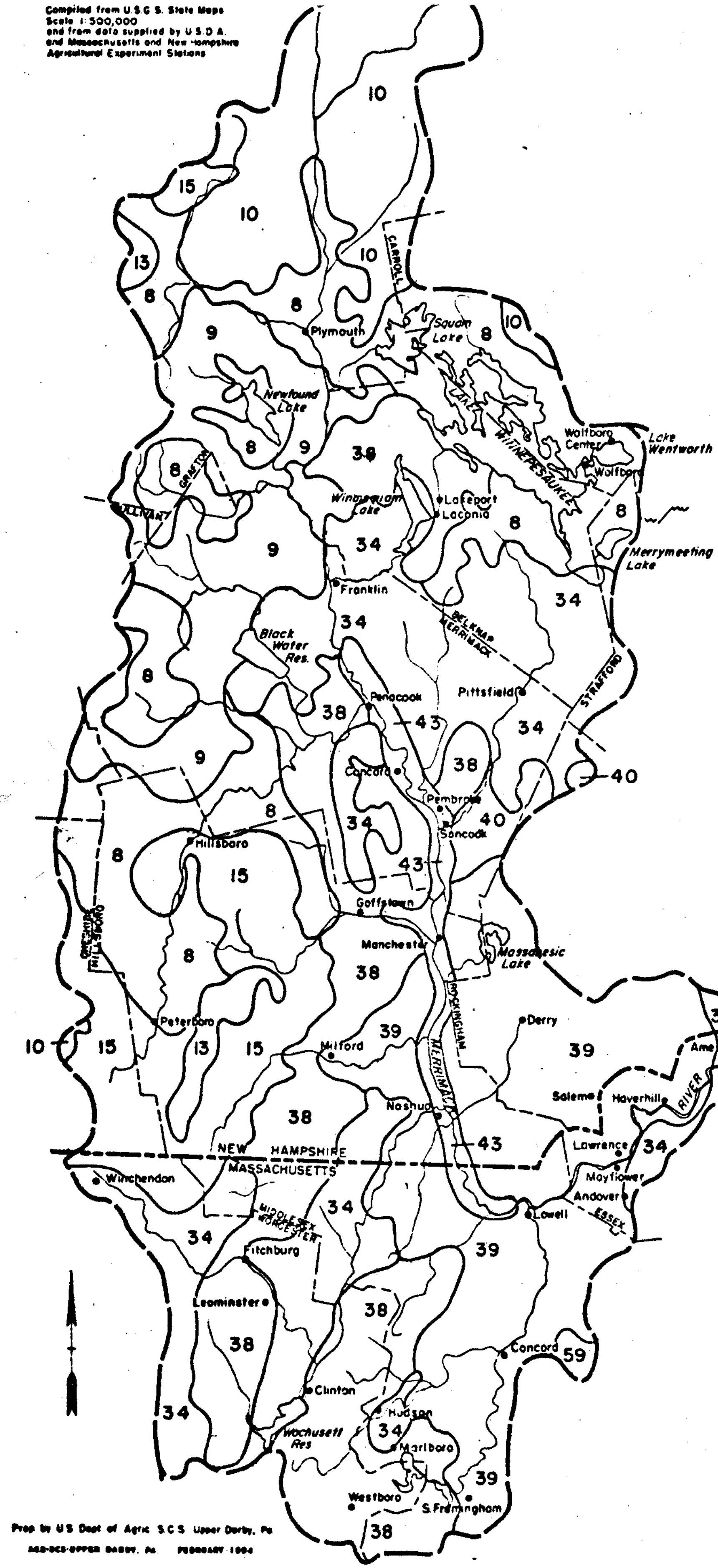
The vegetation of New England and the Merrimack River Basin is mixed deciduous and coniferous forest. The occurrance of forest species are determined by soil, time, topography and climatic factors. Spruce, fir, aspen and birch predominate in the northern part of the Basin and white, red and pitch pine in the south. Oak and maple are dispersed throughout the Basin. At the present time about 75 percent of the Basin has forest vegetation which has been increasing in recent years as agricultural lands are permitted to revert back to "natural" vegetation.

All of the previously mentioned factors lead to the development of numerous distinct soil types which are grouped into soil associations. The soil associations of the Merrimack River Basin are given on Plate 1 and described in Table B1.

As the pastures and fields revert back to forest, the number of deer, hare, rabbit, grouse, and woodcock populations have been declining. This is also true of a wide variety of small animals and song birds associated with such habitats.

b. The Rivers

The Merrimack River originates at the junction of the Pemigewasset and the Winnipesaukee Rivers near Franklin, New Hampshire. The course of the River is southerly in New Hampshire but after entering Massachusetts it turns abruptly East and meets the Atlantic Ocean at Newburyport, Massachusetts. The River is 116 miles long with the lower 22 miles subject to tidal action. In the 94 miles above tidewater the



LEGEND

- 8 Hermon, Colton, Whitman
- 9 Hermon, Colton, Whitman
- 10 Hermon, Rockland
- 13 Berkshire, Rockland
- 15 Berkshire, Marlow, Whitman
- 34 Charlton, Paxton, Leicester
- 36 Scantic, Merrimac, Hollis
- 38 Gloucester, Merrimac, Leicester
- 39 Gloucester, Merrimac, Leicester
- 40 Gloucester, Plymouth, Whitman
- 43 Ondawa, Colton, Merrimac
- 59 Unclassified Urban Land

Plate 1

MERRIMACK RIVER BASIN MAP
SOIL ASSOCIATIONS

NEW ENGLAND - NEW YORK INTER - AGENCY COMMITTEE
FEBRUARY, 1954

SCALE IN MILES

PLATE 52
CHAPTER XV

TABLE B1 - SOIL ASSOCIATIONS IN MERRIMACK RIVER BASIN

Soil Associations	Number 1/	Principal Rock Type in Glacial Parent Material	Dominant Great Soil Group	Percent of Area	Use
Hermon (a), Colton (a), Whitman (b)	8	Acid crystalline rocks	(a) Podzol (b) Humic Gley	16.2	Some farming, rolling and hilly
Hermon (a), Colton (a), Whitman (b)	9	Acid crystalline rocks	"	9.1	Less farming, hilly and steep
Hermon, Rockland (ledgy and rock outcrop)	10	Acid crystalline rocks	Podzol	13.3	Forested
Berkshire, Rockland	13	Gray quartz schist	Podzol	1.3	Forested, mountainous
Berkshire (a), Marlow (a), Whitman (b)	15	Fine grained schist, some granite	(a) Podzol (b) Humic Gley	7.2	Generally in agriculture
Charlton, Paxton, Leicester	34	Fine grained schist	Brown Podzolic	18.9	" " "
Scantic, Merrimac, Hollis	36	Granite and schist	" "	1.5	Considerable farming
Gloucester, Merrimac, Leicester	38	Acid crystalline rocks	Brown Podzolic Low Humic Gley	12.9	Rolling and hilly
Gloucester, Merrimac, Leicester	39	Acid crystalline rocks	Brown Podzolic Low Humic Gley	17.9	More level-considerable farming
Ondawa (a), Colton (b), Merrimac (c)	43	Acid crystalline rocks	(a) Alluvial (b) Podzol (c) Brown Podzolic	1.7	Bottomland and terraces-considerable farming

1/ Numbers refer to those on Soil Association Map, Plate 1.

294 foot gradient of the river is controlled by six dams which make some 70 percent of the length of river slack water. All of the impoundments are relatively small in total volume and therefore have little retention time.

The Merrimack River has several tributaries. In this study the Winnipesaukee and the Nashua Rivers have been of prime concern. The Winnipesaukee River drains the major lake of New Hampshire (Lake Winnipesaukee) and is well controlled by dams throughout its 23 mile length. The Nashua River starts west of Fitchburg, Massachusetts and flows north to join the Merrimack at Nashua, New Hampshire. The North Branch of the Nashua which bisects Fitchburg and Leominster, Massachusetts is small and highly polluted by municipal and industrial wastes. Biotic activity is therefore greatly reduced. From the junction of the North and South Branches of the Nashua River near Clinton, Massachusetts the Nashua River has a low gradient and is choked with brush and weeds.

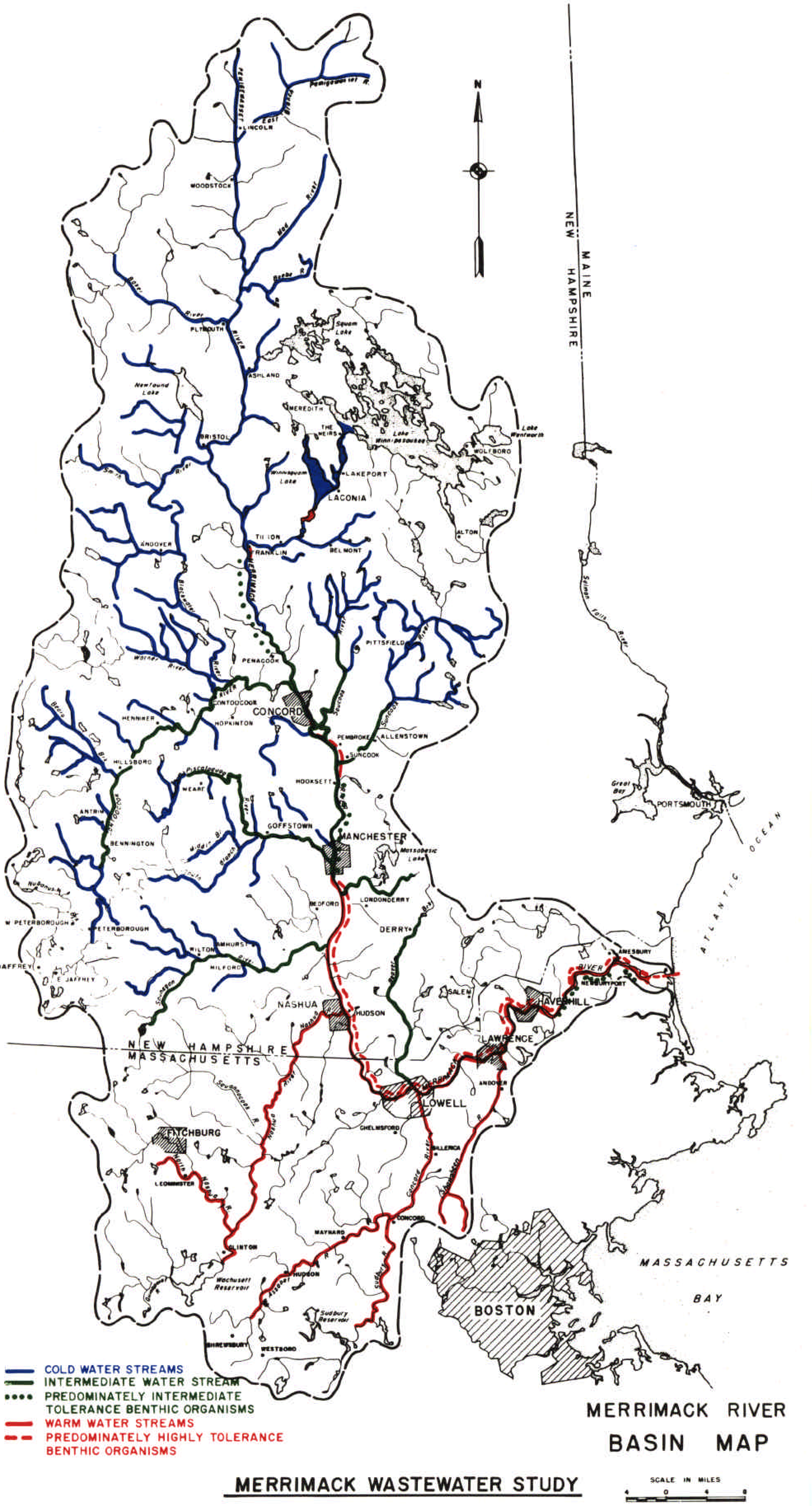
The Merrimack River Basin can be divided into three classes of aquatic communities based on water temperature and using fish species as indicators. The basin above Penacook, New Hampshire is classified as a cold water community and is characterized by the presence of the Eastern Brook Trout (Salvelinus frontinalis), which cannot tolerate temperatures greater than 68°F.

The aquatic community from Penacook to Manchester, New Hampshire is considered intermediate in temperature, based on the presence of small mouth bass (Micropterus dolomieui) and walleye (Stizostedion vitreum), which have a maximum temperature tolerance of 75°F.

The southern portion of the Basin, including the Nashua River is considered a warm water community. The predominant fish species include chain pickerel (Esox niger), yellow perch (Perca flavescens) and pumpkinseed (Lepomis gibbosus). These species are not adversely affected until the water temperature reaches a point greater than 80°F.

The extent of these aquatic communities is shown on Plate B2. The tributaries for which there is no indication of classification indicate a lack of data. In general, these tributaries would fall into the same classification as the other rivers in the same area, modified by the areal topography.

A river can also be classified according to its distribution of benthic organisms. Portions of the Merrimack River have been classified as having a bottom fauna consisting of organisms highly tolerant to pollution and those bottom fauna intermediately tolerant to pollution (Plate B2). No reaches of the Merrimack that have been studied contain predominantly benthic organisms sensitive to pollution. Although benthic organisms are usually distributed according to their temperature tolerances, the response in the Merrimack River is masked by the high degree of pollution at specific points. On the main stem of the Merrimack River, intermediate tolerance organisms predominated from slightly below Franklin to Penacook, New Hampshire, from Hooksett to Manchester, New Hampshire, and in three short segments below Haverhill, Massachusetts. Highly tolerant organisms predominated in a short reach below Franklin, New Hampshire, from north of Concord to Hooksett, New Hampshire, and the entire reach of River from Manchester, New Hampshire to below Haverhill, Massachusetts. The rest of the River from Haverhill to the



MERRIMACK RIVER BASIN MAP

MERRIMACK WASTEWATER STUDY

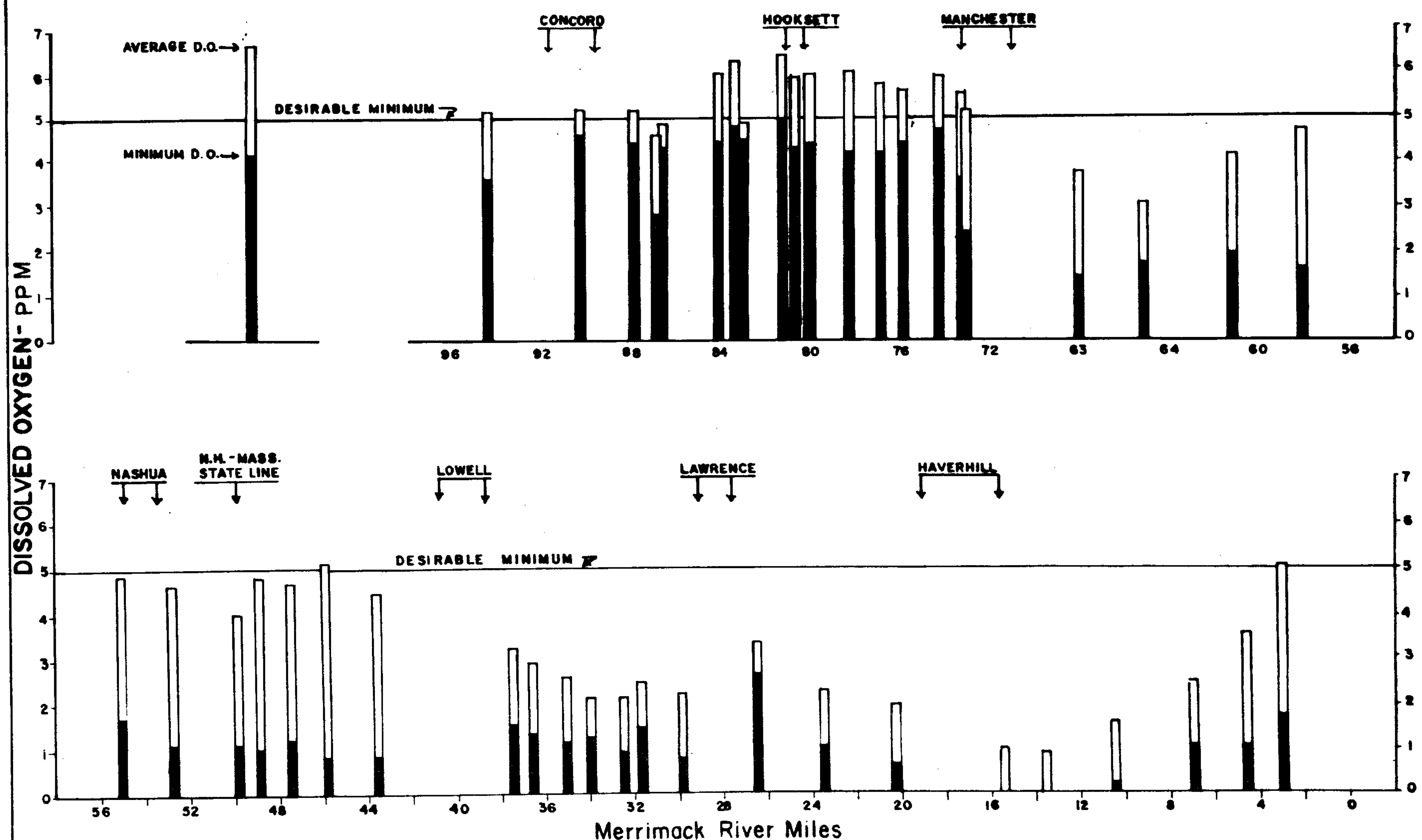
PLATE 2

Atlantic Ocean has predominantly tolerant organisms where it is not classified as intermediate. Sufficient data does not exist to characterize the other rivers within the Basin. Visual observation of the Nashua River leads to the conclusion that the River has only highly tolerant organisms. Streams in the upper portions of the Basin would probably contain organisms on the sensitive side of the scale. In general, the distribution is related to the degree of development along the River.

The level of dissolved oxygen in a river is a major factor in determining the ability of a river to support a viable ecologic community. The dissolved oxygen levels of the Merrimack River and its tributaries often reach critical low levels at the present time. Figure B1 shows the average dissolved oxygen levels of the Merrimack River during the summers of 1964 and 1965. Waters with greater than 5 ppm dissolved oxygen are adequate to support fish life, however many portions of the River are below this level much of the summer.

c. The Merrimack Estuary

The maximum length of the Merrimack Estuary is 6.0 nautical miles (9 statue miles) (Plate 3). The maximum width at high waters is 1.6 nautical miles (2.4 statue miles) at low water the maximum width is 0.7 nautical miles (1.05 statue miles). The area of the Estuary at mean high water is 3,957 acres; at mean low water the area is 2,110 acres. Thus the intertidal area is 1,847 acres or 46.7% of the total area. A total of 4,208 acres of salt marsh drains into the Merrimack Estuary. The total volume of the Estuary at mean high water is



DISSOLVED OXYGEN IN MERRIMACK RIVER

JUNE, JULY, AUGUST & SEPTEMBER 1964-1965

Figure B1
Courtesy FWPCA

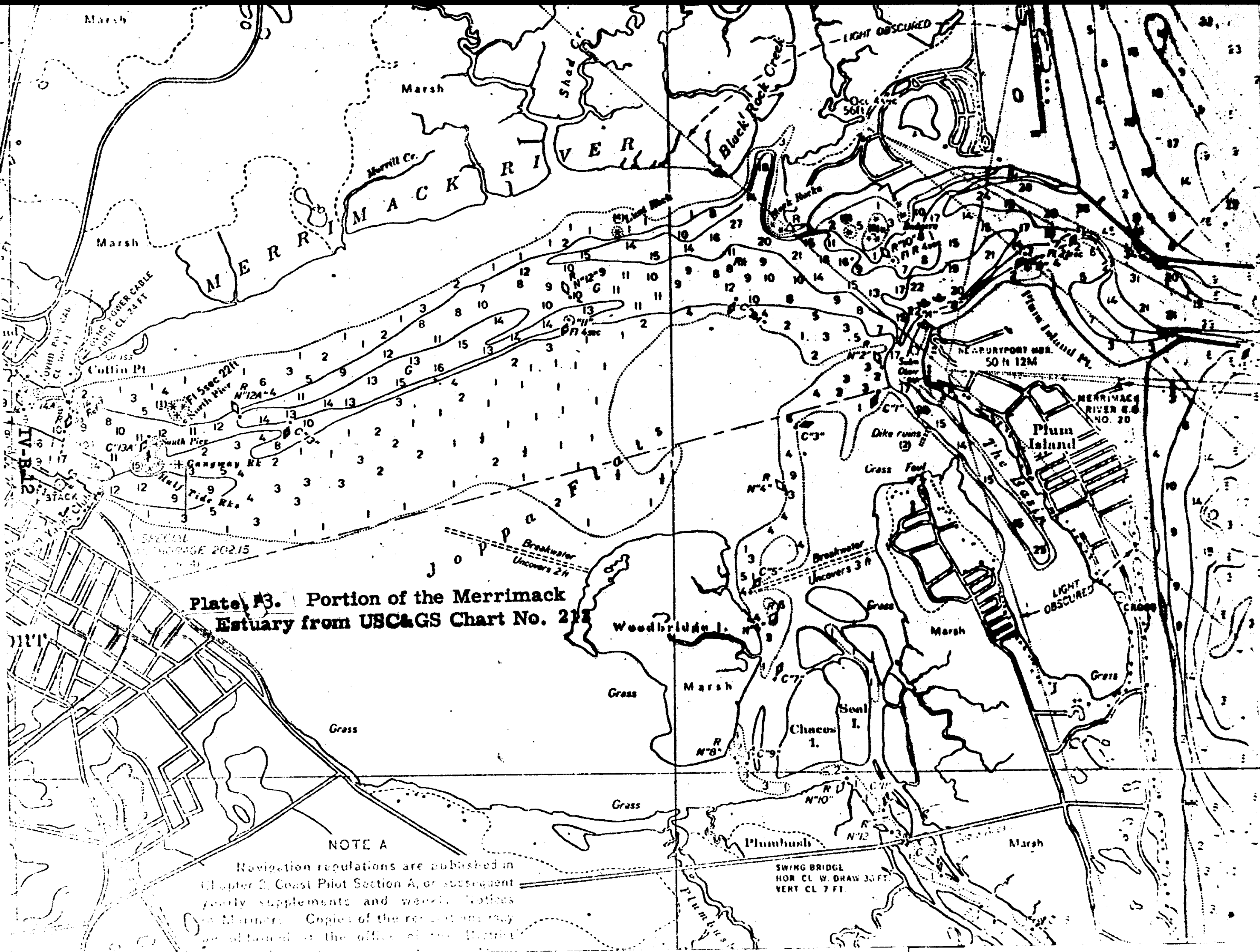


Plate F3. Portion of the Merrimack Estuary from USC&GS Chart No. 21_

1,884,405,600 cubic feet; at mean low water it is 835,829,300 cubic feet. Consequently, the volume of water in the Estuary at mean low water is only 44.4% of that in the Estuary at mean high water. This relation makes for the very high flushing rate of 56% per tidal cycle. This is a high flushing rate in comparison to other estuaries.

The mean flow of the River is about 630 million cubic feet per day. This represents about 33% of the volume flushed on each tidal cycle, or twice each day. At the time of spring floods, the peak flow only amounts to about 5% of the volume flushed on each tidal cycle; at times of minimal flow the River only contributes 0.3% of the volume flushed on each tide. Thus, given the present grossly polluted condition of the River to all intents and purposes the Estuary acts like a giant toilet bowl which is flushed twice a day. Thus it is clear that small variations in overflow probably will not have any great effect on the distribution of physical properties in the Estuary.

A factor which contributes both to the high flushing rate and the high productivity of the Estuary is its relative shallowness. Approximately 50% of the area of the Estuary is less than 5 feet deep at low tide; about 90% of the area of the Estuary is covered by less than 18 feet of water at low tide. Light transmission values observed in July, 1971 show that when the bottom is overlain by river water, plants receive sufficient light to grow at a depth of 18 feet. But when the bottom is overlain by ocean water, sufficient light for the growth of plants would penetrate to 60 feet which is deeper than any part of the Estuary. Thus between 90 and 100% of the area of the Estuary is available for the growth of plants.

The Merrimack Estuary is typically characterized by sharp boundaries between fresh and salt water. During times of high river flow the fresh water flows out over the intruding salt water which thus forms what is called a "salt wedge". At such times the boundary between fresh and salt water, at the surface, may reach as high as the town of Newburyport; the same boundary at the bottom may be much further upstream. When the above condition holds, the Estuary is said to be stratified. Under conditions of low flow (less than about 3,000 cubic feet per second, which can occur in late summer and probably in mid-winter too) the tendency for fresh water to override the salt water is much reduced, and the boundary between the two may become nearly vertical. At such times the Estuary is said to be non-stratified. Another factor which affects the position of the boundary between the fresh and salt water results from the rotation of the earth. The effect of this is to tilt the boundary between the fresh and salt water upward toward the right or north side of the Estuary. This causes the "ponding" of fresh water over Joppa Flat on the south side of the Estuary. Sediment falling from this ponded fresh water is probably one reason why Joppa Flat is where it is.

At the front between river water and ocean water, in a distance of less than a meter (approximately one yard) the temperature may change by 18°Fahrenheit and the salinity may change by as much as 18 parts per thousand. The front itself moves up and down the Estuary with the tide. Although there is some mixing between river water and ocean water, it is useful to think of there being two water masses in the Estuary whose position changes with the stage of the tide. The physical chemical properties of these two water bodies will be discussed separately.

The properties of the ocean water entering the Merrimack Estuary probably have not changed much since colonial times or before. The salinity varies from 30 to 33 parts per thousand throughout the year; the temperature varies from 30°F to 59°F over a year's time. The values for nitrate, nitrite and phosphate content are comparable with those found offshore in the Gulf of Maine. The dissolved oxygen content of ocean water is always greater than 10.0 ppm (parts per million).

In 1964, the detergent content of the ocean water ranged from 0.0 to 0.2 ppm which fell within the 0.5 ppm limit for drinking water set by the U. S. Public Health Service. No data on the pesticide content of ocean water seems to be available. All things taken together indicate that the ocean water entering the Merrimack Estuary is clean and does not bring in additional pollutants with it.

The temperature of river water entering the Estuary varies with the season. The annual range is from 30°F to 86°F. The mean summer temperature is 75°F. Depending on the state of mixing, the salinity of river water may vary from 0 to 15 parts per thousand. The river water in the Merrimack Estuary contains high concentrations of nutrients and bacteria. All of these are typical of a body of water receiving domestic sewage in large amounts. In addition to these physical-chemical properties, the river water has a less than pleasant odor and color. Furthermore, although the River contains enormous amounts of sludge in its lower reaches arising from human sewage and industrial wastes, none is evident in the Estuary. This is clearly a reflection of the Estuary's very efficient tidal flushing mechanism.

The values obtained in late June 1971 for the nutrients NO_3, NO_2, and phosphate in the River and the Estuary are shown in Table B2. These values show a consistent rise in nutrient content as the River flows past the various cities along its length. The values observed in the Estuary are slightly less than those observed at Amesbury, which presumably are a result of minimal flow so they should be representative of the higher values to be found in the Estuary.

A dissolved oxygen content of less than 5.0 ppm is generally considered to be detrimental to fish populations as well as to populations of other aquatic organisms. During the period 1936-45 the mean oxygen content of the River above Newburyport was 5.0 ppm with a minimum of 1.0 ppm. For the period 1956-61 the mean oxygen content was 5.0 with a minimum of 2.4 ppm. In 1964 no values less than 5.0 ppm dissolved oxygen were found in the Estuary. Thus it appears that, although the total load of sewage carried by the River has increased steadily, the total load of organic material entering the River has decreased.

TABLE B2 - NUTRIENT CONTENT OF WATER

SAMPLES TAKEN AT VARIOUS LOCATIONS ON JUNE 27, 1971

Location	NO_3	NO_2	PO_4
	(in millegrams per liter)		
Plymouth, New Hampshire	0.496	0.0041	0.0075
Above Manchester, New Hampshire	0.154	0.0105	0.0301
Nashua, New Hampshire	0.647	0.0354	0.1927
Lowell, Massachusetts	1.063	0.0727	0.1683
Lawrence, Massachusetts	1.534	0.1587	0.3215
Haverhill, Massachusetts	1.910	0.2070	0.4371
Groveland, Massachusetts	1.882	0.2093	0.5790
Amesbury, Massachusetts	1.724	0.2024	0.1824
Estuary in River Water	1.519	0.1196	0.2961
Estuary in Ocean Water	0.051	0.0193	0.0705
Gulf of Maine Surface Water	0.004	0.0046	0.0188
Gulf of Maine Deep Water	0.217	0.0138	0.0564

On the whole, it appears that the Merrimack Estuary may now be in the best condition it has been in the last 100 years. About 70% of the industrial waste has been removed by the closing of many mills and it appears that pollution with domestic sewage has not yet placed a load on the Estuary similar to that existing in the first part of this century. However, with continued population growth, if nothing is done the gains realized in the past two decades may well be lost.

At present the finish fauna of the Merrimack Estuary consists of about 50 species (Table B3). Of these, seven are basically fresh water fishes; three species are anadromous, i.e. they breed in fresh water but live as adults in salt water, and one species, the Americal Eel, is catadromous, that is they spend their adult life in fresh water and breed in salt water. There is no indication that populations of any of the non-migratory fish are being affected adversely by either the up-river pollution, or pollution within the Estuary.

Populations of migratory fish such as the American eel, the blue-back herring and the alewife have been decimated by the construction of dams upstream and by the appalling condition of the River upstream from the Estuary. The entire population of such valuable fish as the Atlantic salmon, the shad, the hickory shad, and the sturgeon have been extirpated by the combination of upstream pollution and dams. As a result, the sport and commercial fisheries must subsist on such predacious oceanic fish as are attracted to the Estuary by the vast numbers of bait-fish which live there. As good as the fishing may seem now, it is only a shadow of its former glory.

TABLE B3: FISH OF THE MERRIMACK ESTUARY 2/

Class: Chondrichthyes

- Order: Squaliformes (Selachii)
  - Family: Squalidae — dogfish shark
    - *Squalus acanthias* — spiny dogfish
- Order: Rajiformes (Batoidei)
  - Family: Rajidae — skates
    - *Raja binoculata* — big skate
    - *Raja erinacea* — little skate
    - *Raja laevis* — barndoor skate

Class: Osteichthyes

- Order: Clupeiformes (Isospondyli)
  - Family: Clupeidae — herrings
    - *Alosa aestivalis* — blueback herring
    - *Alosa pseudoharengus* — alewife
    - *Clupea harengus harengus* — Atlantic herring
  - Family: Salmonidae — trouts
    - *Salmo trutta* — brown trout
  - Family: Osmeridae — smelts
    - *Osmerus mordax* — American smelt
- Order: Cypriniformes (Ostariophysi)
  - Family: Cyprinidae — minnows and carps
    - *Cyprinus carpio* — carp
    - *Notemigonus crysoleucas* — golden shiner
    - *Notropis hudsonius* — spottail shiner
  - Family: Catostomidae — suckers
    - *Catostomus commersoni* — white sucker
  - Family: Ictaluridae — freshwater catfish
    - *Ictalurus nebulosus* — brown bullhead
- Order: Anguilliformes (Apodes)
  - Family: Anguillidae — freshwater eels
    - *Anguilla rostrata* — American eel
  - Family: Congridae — conger eels
    - *Conger oceanicus* — conger eel
- Order: Cyprinodontiformes (Microcyprini)
  - Family: Cyprinodontidae — killifishes
    - *Fundulus heteroclitus* — mummichog
- Order: Gadiformes (Anacanthini)
  - Family: Gadidae — codfishes and hakes
    - *Gadus morhua* — Atlantic cod
    - *Melanogrammus aeglefinus* — haddock
    - *Microgadus tomcod* — Atlantic tomcod
    - *Pollachius virens* — pollock
    - *Urophycis chuss* — squirrel hake
- Order: Gasterosteiformes (Thoracostei, Hemibranchii, Lophobranchii, and Solenichthyes)
  - Family: Gasterosteidae — sticklebacks
    - *Apeltes quadracus* — fourspine stickleback
    - *Gasterosteus aculeatus* — threespine stickleback
    - *Pungitius pungitius* — ninespine stickleback
  - Family: Syngnathidae — pipefishes and seahorses
    - *Syngnathus fuscus* — northern pipefish
- Order: Perciformes (Percomophi; Acanthopterygii)
  - Family: Serranidae — sea basses
    - *Roccus americanus* — white perch
    - *Roccus saxatilus* — striped bass
  - Family: Centrarchidae — sunfishes
    - *Lepomis gibbosus* — pumpkinseed
    - *Lepomis macrochirus* — bluegill
  - Family: Percidae — perches
    - *Perca flavescens* — yellow perch
  - Family: Scombridae — mackerels and tunas
    - *Scomber scombrus* — Atlantic mackerel
  - Family: Cottidae — sculpins
    - *Hemitripterus americanus* — sea raven
    - *Myoxocephalus aeneus* — grubby
    - *Myoxocephalus octodecemspinosus* — longhorn sculpin
  - Family: Cyclopteridae — lumpfishes and snailfishes
    - *Cyclopterus lumpus* — lumpfish
    - *Liparis atlanticus* — seasnail
  - Family: Ammodytidae — sand lances
    - *Ammodytes americanus* — American sand lance
  - Family: Pholidae — gunnels
    - *Pholis gunnellus* — rock gunnel
  - Family: Stichaeidae — pricklebacks
    - *Ulvaria subbifurcata* — radiated shanny
  - Family: Zoarcidae — eel-pouts
    - *Macrozoarces americanus* — ocean pout
  - Family: Atherinidae — silversides
    - *Menidia menidia* — Atlantic silverside
- Order: Pleuronectiformes (Heterosomata)
  - Family: Bothidae — lefteye flounders
    - *Paralichthys oblongus* — fourspot flounder
    - *Scophthalmus aquosus* — windowpane
  - Family: Pleuronectidae — righteye flounders
    - *Glyptocephalus cynoglossus* — witch flounder
    - *Hippoglossoides platessoides* — American plaice
    - *Limanda ferruginea* — yellowtail flounder
    - *Liopsetta putnami* — smooth flounder
    - *Pseudopleuronectes americanus* — winter flounder
- Order: Lophiiformes (Pediculati)
  - Family: Lophiidae — goosefishes
    - *Lophius americanus* — goosefish

2/ Jerome, W. C. Jr., A. P. Chesmore, C. O. Anderson, Jr., and F. Grice. **A Study of the Marine Resources of the Merrimack River Estuary.** Monograph Series No. 1, Division of Marine Fisheries, Department of Natural Resources, the Commonwealth of Massachusetts, June 1965.

Other than those species which are important as food or bait, very little is known about the burrowing and bottom-dwelling fauna of the Merrimack Estuary. Oxygen levels are relatively high above the sediment-water interface, so there is no reason to believe that benthic invertebrate fauna should be radically different from that of other similar estuaries. However, the sediments throughout the Estuary are anoxic as a result of the deposition of the large amount of organic material carried by the River. As a consequency, they are characterized by a hydrogen-sulfide odor. This lack of oxygen in the sediments combined with the relatively harsh oceanographic environment limits the population to those species which are very tolerant of changes in temperature and salinity and which do not rely on oxygenated water in the sediments to survive. As a result, the macroscopic fauna is quite limited.

The most common macroscopic invertebrate in the Estuary is the softshell clam. Associated with the softshell clam is the clam worm, the blood worm, the duck clam, and the blue mussel.

A list of the important species of plants found in the Merrimack Estuary is given in Table B4. The species are important in two ways to the animals living in the Estuary. First, they provide shelter for the young of many species of fish and thus contribute to the importance of estuaries as fish nurseries. The second way these plants are important to estuarine animals is that they provide a large quantity of food, both directly and in the form of

TABLE B4: PLANT SPECIES OF THE MERRIMACK ESTUARY 2/

Scientific Name	Common Name
ALGAE	
Class: CHLOROPHYCEAE	GREEN ALGAE
Chaetomorpha sp.	
Derbesia vaucheriaformis	
Enteromorpha mathinata	
Monostroma sp.	
Ulothrix flacca	
Ulva latuca	sea lettuce
Class: RHODOPHYCEAE	RED ALGAE
Chondrus crispus	Irish moss
Phycodrys rubens	
Class: PHAEOPHYCEAE	BROWN ALGAE
Agarum cribrosum	holed kelp
Ascophyllum nodosum	rock weed
Desmarestia aculeata	
Fucus spiralis	rock weed
Fucus vesiculosis	rock weed
Laminaria saccarina	kelp
VASCULAR PLANTS	
Acorus calamus	sweet flag
Artemisia stelleriana	dusty miller
Eleocharis sp.	spike rush
Lythrum salicaria	swamp loosestrife
Pontederia cordata	pickerel weed
Sagittaria latifolia	duck potato
Scirpus americanus	three square bull rush
Scirpus validus	soft stem bull rush
Spartina alterniflora	salt water cord grass
Spartina patens	high water cord grass
Spartina pectinata	fresh water cord grass
Zizania aquatica	wild rice

2/ Op. Cit.

nutrients which enrich other areas of the Estuary. There is no evidence that the plant population of the Merrimack Estuary is adversely affected by the pollution of the Merrimack River. On the contrary, the plants living in the Estuary very probably benefit from the presence of nutrients brought into the Estuary by the River.

The Plum Island marshes and waters of the Merrimack Estuary are renowned for the concentrations of marsh birds, shore birds and waterfowl that are found there. Gunning for waterfowl has been practiced there since colonial times. In recent years it has been a favorite spot for bird-watchers and students of ornithology. These waterfowl populations constitute approximately eight percent of the Commonwealth of Massachusetts costal waterfowl wintering pupulations. The major species inhabiting the marshes and bays of the Estuary are listed in Table B5 by categories; i.e., geese, sea ducks, dabbling ducks, diving ducks. The data represent average values for the five-year period 1965 through 1969. Under the "Remarks" column information on feeding habits and feeding area preferences are presented. Species counts are taken each year by the Massachusetts Department of Natural Resources in January. The numbers represent trends in abundance and not total numbers. Data from band recoveries indicate the counts may be only one-third to one-quarter the total number of birds present on a given area.

TABLE B5: NUMBERS AND FEEDING CHARACTERISTICS OF WATERFOWL SPECIES FREQUENTING THE MERRRIMACK RIVER ESTUARY DURING THE FALL AND WINTER

Species	Number of Individuals (1965-1967)		Remarks		
	Average	Range	Feeding Habitat	Ratio Animal: Vegetable	Major Plant and Animal Type
Geese: Canada Goose	280	92-560	Salt marsh, shallow creeks and flats, primarily along west side of Plum Island.	Tr.:99+	Cordgrass, widgeongrass, sea lettuce, naiad, glasswort, eelgrass, saltgrass, bulrush
Dabbling Ducks: Black Duck	8,882	6,800-10,110	Salt marsh, shallow creeks and flats to a depth of about 3 feet; primarily around Woodbridge Island, Joppa Flats, and west of Plum Island	50:50 (in late winter the diet may be almost entirely animal	Mollusks (mostly univalves), crustaceans, immature forms of aquatic insects. Species taken include *Mya arenia*, Hydrobia sp., *Mytilus edalis*; *Gemma gemma*, Neeris sp., *Melampus bidentatus*, Littorina sp., and Gammarus. Plants include cordgrass, widgeongrass, eelgrass, arrowgrass, and water hemp.
Diving Ducks: Bufflehead and Goldeneye (counts combined)	1,035	400-1,900	Bays, deep rivers to depths exceeding 30 ft; locate in Newburyport Harbor and open water areas of Plum Island Sound.	80:20 (both species)[1]	Bufflehead: insects, mollusks (mostly univalves), naiad, widgeongrass. Goldeneye: crustaceans (50 per cent crabs), insects, some mollusks and fishes, widgeongrass, eelgrass.
Scaup	1,060	100-3,800	Same as above	50:50	Mollusks, larval insects, amphipods, crabs, barnacles, eelgrass, pondweeds.
Sea Ducks: Scoters	312	0-550	Offshore on shoal areas and in deep bays; primarily at the Merrimack jetty and north of Woodbridge Island	94:6	Both species: mussels, barnacles, insects, fishes, echnioderms, eelgrass, kelp, muskgrass, widgeongrass. Vegetable matter may comprise about 21 percent of diet in the fall.
Eiders	46	0-125		94:6	

[1] Personal Communication, Warren W. Blanden, Chief of Wildlife Research, Massachusetts Department of Natural Resources

Extensive areas of excellent nesting habitat for marsh birds and some waterfowl species exist despite the encroachment of man. Thousands of ducks and geese winter in the area, but the largest numbers of birds are present during spring and fall migrations when flights of ducks and geese are passing through and hordes of sandpipers and plovers scour the tidal flats feeding on tiny marine organisms.

The present level of pollution in the Merrimack River has had little direct effect on these Estuary birds although it has affected many of the animals and plants upon which they feed. The survival of fish and shellfish larvae has been reduced in the areas of heavy pollution in the River whereas some of the pollutants have served to nutrify the marshes around the River mouth.

2. HYGIENE

In general, the incidence of water associated disease appears to be small in the Merrimack River Basin. Outbreaks, when they occur, are small in extent and time. However, a determination of the number of isolated cases of disease, particularly *Salmonella* infections, which occur in the Basin has not been made. The overall situation can probably be best described as one of potential or unknown hazard. As an indication of this hazard, the coliform densities in the Merrimack River have been examined. The determination of coliform densities in the Merrimack River was the result of several intensive studies undertaken during the summer months of 1964 and 1965 by the Federal Water Pollution Control Administration. These intensive studies were supplemented by subsequent sampling periods during other seasons of the year.

The large increase in coliform bacteria at Concord, Manchester and Nashua, New Hampshire, resulted from the discharge of raw sewage at these points (Figure B2). The Merrimack River had an average coliform density (MF) of 249,000 per 100 ml and an average fecal coliform density of 18,600 per 100 ml below Manchester during the summer months. Water acceptable for bathing purposes, according to the New Hampshire Water Use Classification and Quality. Standards, must have coliform bacteria counts not more than 240 MPN per 100 ml.

During the summer of 1964 the waste discharge at Nashua, New Hampshire and Lowell, Lawrence and Haverhill, Massachusetts produced excessive coliform densities (Figure B3). Just below the

COLIFORM BACTERIA IN NEW HAMPSHIRE SECTION OF MERRIMACK RIVER - 1965

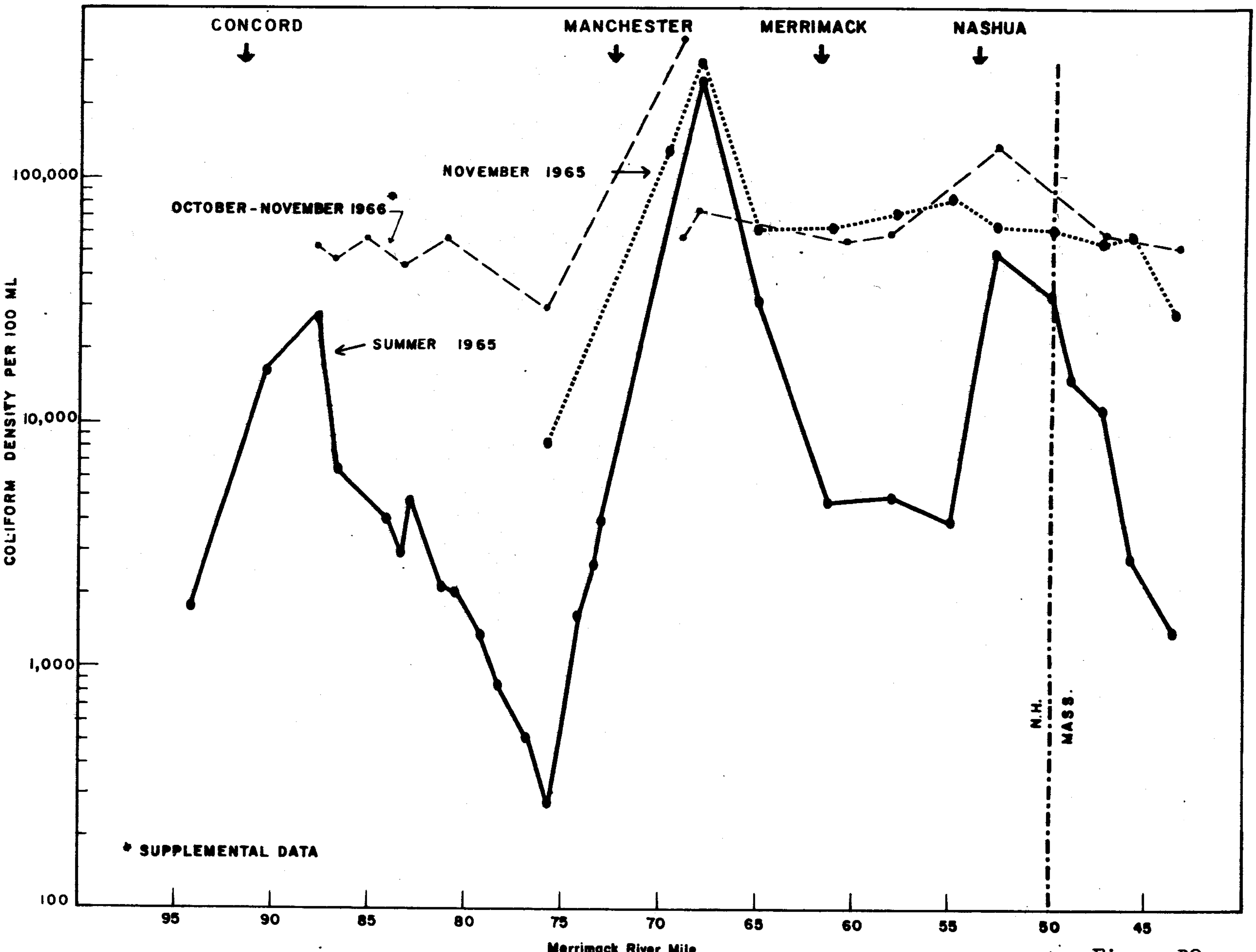


FIGURE B2

Figure B2
Courtesy FWPCA

COLIFORM BACTERIA IN MERRIMACK RIVER - 1964

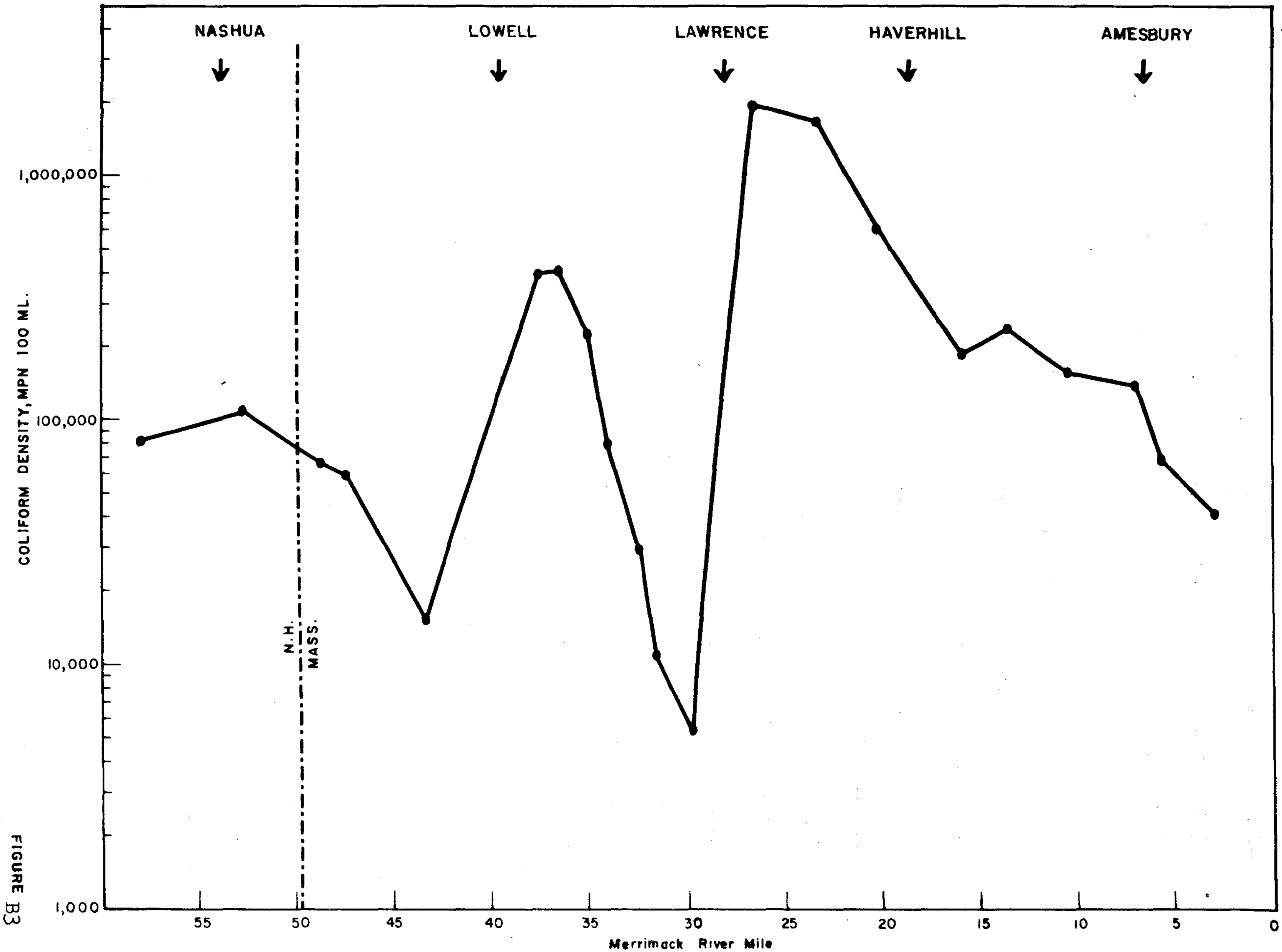


FIGURE B3

Figure B3
Courtesy FWPCA

state line the total and fecal coliform bacteria values were 67,000 and 14,600 MPN per 100 ml, respectively. At the Lowell water intake the total coliform density averaged 15,100 MPN per 100 ml and the fecal coliform density averages 2,500 MPN per 100 ml.

The river had the highest coliform density in the Lawrence to Haverhill reach. The average total coliform density was 1,910,000 MPN per 100 ml and the average fecal coliform density was 213,000 MPN per 100 ml below Lawrence. At this point, a maximum value of 9,200,000 MPN per 100 ml was obtained for the total coliform density and a maximum of 542,000 MPN per 100 ml for the fecal coliform density. The presence of these high coliform densities indicate a hazard to health when the water is consummed.

The quality of Merrimack River water at many points exceeds the limits for a Group III water, i.e., one needing treatment by complete conventional means including coagulation, sedimentation, rapid granular filtration and pre and post disinfection. The total coliform density for this group should be less than 20,000 per 100 ml as measured by the monthly geometric mean or less than 4,000 per 100 ml fecal coliform density measured similarly. 3/

Since high coliform densities were found in the river water, vegetables which are usually eaten without cooking and were irrigated with river water were checked for the presence of fecal

3/ Manual for Evaluating Public Drinking Water Supplies, Public Health Service Publication No. 1820.

coliform bacteria. For comparison, vegetables from farms that did not use Merrimack River water were also checked (Table B6). A significantly greater number of fecal coliform were present in vegetables grown on those farms that used Merrimack River water for irrigation then on vegetables from farms that did not.

The California Department of Health Standards for the safe spray irrigation of produce (fruit and vegetables eaten raw) utilizing wastewater state that the wastewater must be disinfected to a median MPN of coliform organisms in samples collected from the irrigation piping not to exceed 2.2 per 100 ml. The median value is determined from the bacteria logical results of the last seven days for which analyses have been completed. Clearly the irrigation of produce with water from the Merrimack River does not meet this criteria. Within the Merrimack River Basin there are no such standards. From the standpoint of the safety of the people in the area it might be well if there were such standards.

The FWPCA also conducted tests for the presence of Salmonella in the Merrimack River. Enteric pathogens of the genus Salmonella were consistently recovered from the Merrimack River in both New Hampshire and Massachusetts, indicating that ingestion of any water from the Merrimack River is a definite health hazard. Salmonella organisms were isolated during each test made at the Lowell and Lawrence, Massachusetts water intakes. Altogether, twenty-one serotypes were recovered from fifty-four isolations. These disease organisms were found in river water having a total coliform density (MF) as low as 180 per 100 ml. The serotypes are listed in Table B7.

TABLE B6

BACTERIA ON VEGETABLES

VEGETABLES IRRIGATED WITH MERRIMACK RIVER WATER

	VEGETABLE	FECAL COLIFORM PRESENT
FARM A		
1.	Cucumber	Yes
2.	Cucumber	Yes
3.	6 carrots	Yes
4.	Bunch leaf lettuce	Yes
5.	Head lettuce	Yes
6.	Bunch radishes	Yes
7.	2 tomatoes	No
8.	1 pint strawberries	No
FARM B		
9.	Cucumber	Yes
10.	Cucumber	Yes
11.	Head lettuce	No
12.	Bunch radishes	Yes

VEGETABLES NOT IRRIGATED WITH MERRIMACK RIVER WATER

	VEGETABLE	FECAL COLIFORM PRESENT
FARM C		
1.	2 tomatoes	No
2.	Bunch radishes with greens	Yes
3.	Head lettuce	No
FARM D		
4.	2 tomatoes	No
5.	Cucumber	No

TABLE B7: SALMONELLA SPECIES RECOVERED

IN THE MERRIMACK RIVER BASIN

S. Bareilly

S. Binza

S. Blockley

S. Chester

S. Cubana

S. Enteritidis

S. Hartford

S. Heidelberg

S. Infantis

S. Livingstone

S. Montevideo

S. Muenster

S. New Brunswick

S. Newington

S. Newport

S. Oranienburg

S. Reading

S. St. Paul

S. Senftenburg

S. Tennessee

S. Typhimurium

A test of the Newburyport, Massachusetts sewage treatment plant effluent taken during intermittent chlorination indicated that this method of disinfection was not effective in killing the pathogens present.

Salmonella were consistently found just below the New Hampshire-Massachusetts state line even when the level of coliform was relatively low. Thus, waters flowing into Massachusetts from New Hampshire endanger the health of persons in Massachusetts.

The Merrimack Estuary also shows high incidence of coliform bacteria. Bacterial densities in the Estuary are greatly affected by the bacterial load of the Merrimack River and the bacterial discharge from the Newburyport sewage treatment plant. The contamination of the Estuary shellfish beds has been severe enough that these beds have been closed commercial since 1926.

Attempts have been made to assess the responsibility for pollution of the Merrimack Estuary. Camp[4/] reported that in 1935, two-thirds of the bacteria over the shellfish beds in the Merrimack River Estuary was attributed to the three upriver communities of Amesbury, Newburyport, and Salisbury. Haverhill, Lawrence, and Lowell were responsible for 29 percent of the total. In August 1964, the FWPCA found that pollution contributions at the head of the Estuary were: Amesbury, 31.4 percent; the Haverhill Region, 17.1 percent; the Lawrence Region, 51.4 percent; and the remaining upstream communities, 0.1 percent.

4/ Camp, T. R. Report on the Disposal of Sewage in the Merrimack River Valley, Commonwealth of Massachusetts, 1947.

The Division of Marine Fisheries, Commonwealth of Massachusetts, classifies waters over shellfish growing areas as:

0-70 total coliforms per 100ml - clean

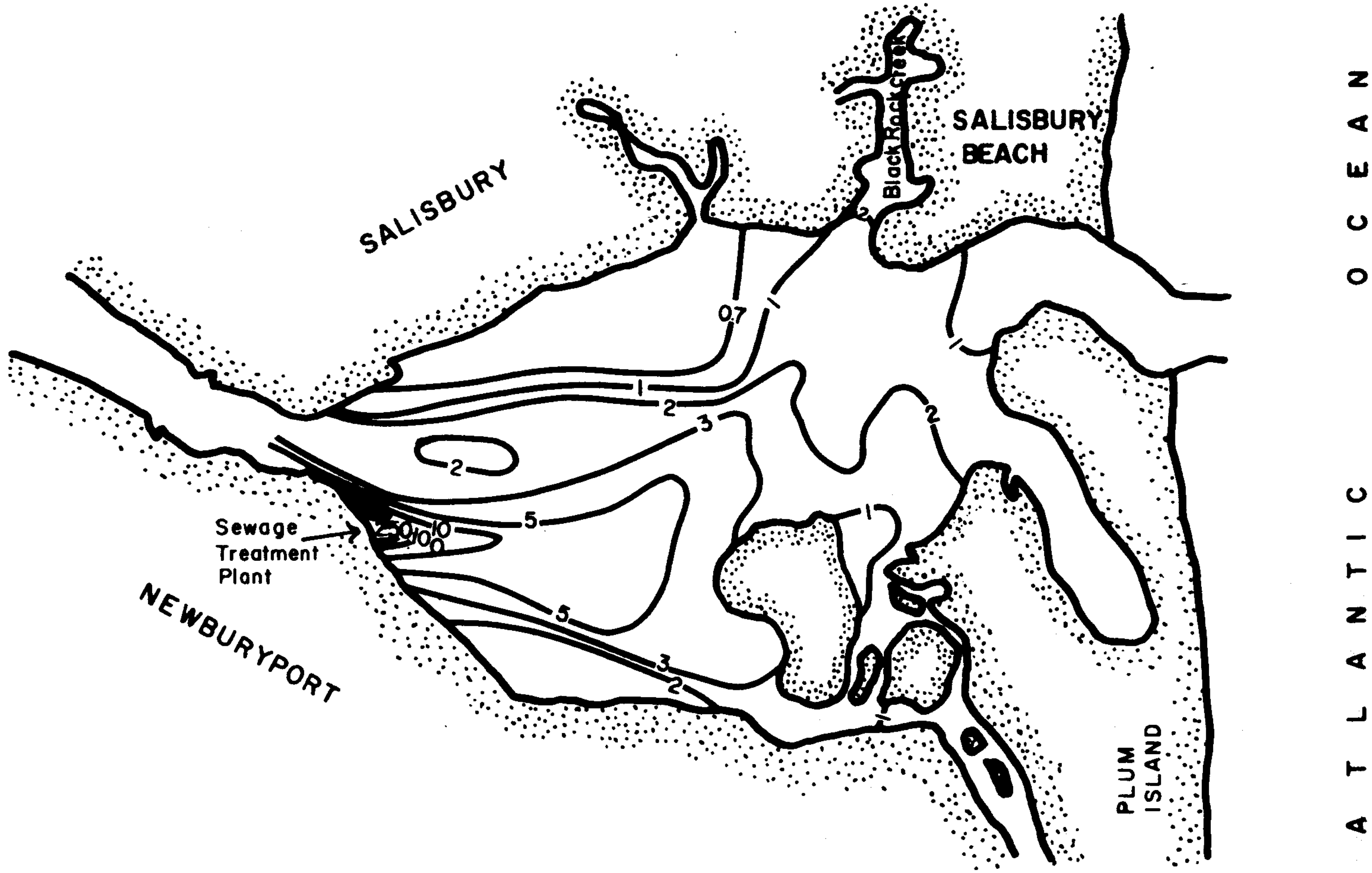
71-700 total coliforms per 100 ml - moderately contaminated

over 700 total coliforms per 100 ml - grossly contaminated

When these standards are applied to the Merrimack Estuary, as shown in Figures B4 and B5, it is grossly contaminated at both high and low tide.

Since the Merrmicak River is clearly polluted with coliform bacteria and Salmonella, it is logical to assume that other pathogenic organisms such as viruses, are present and present a hazard to human health.

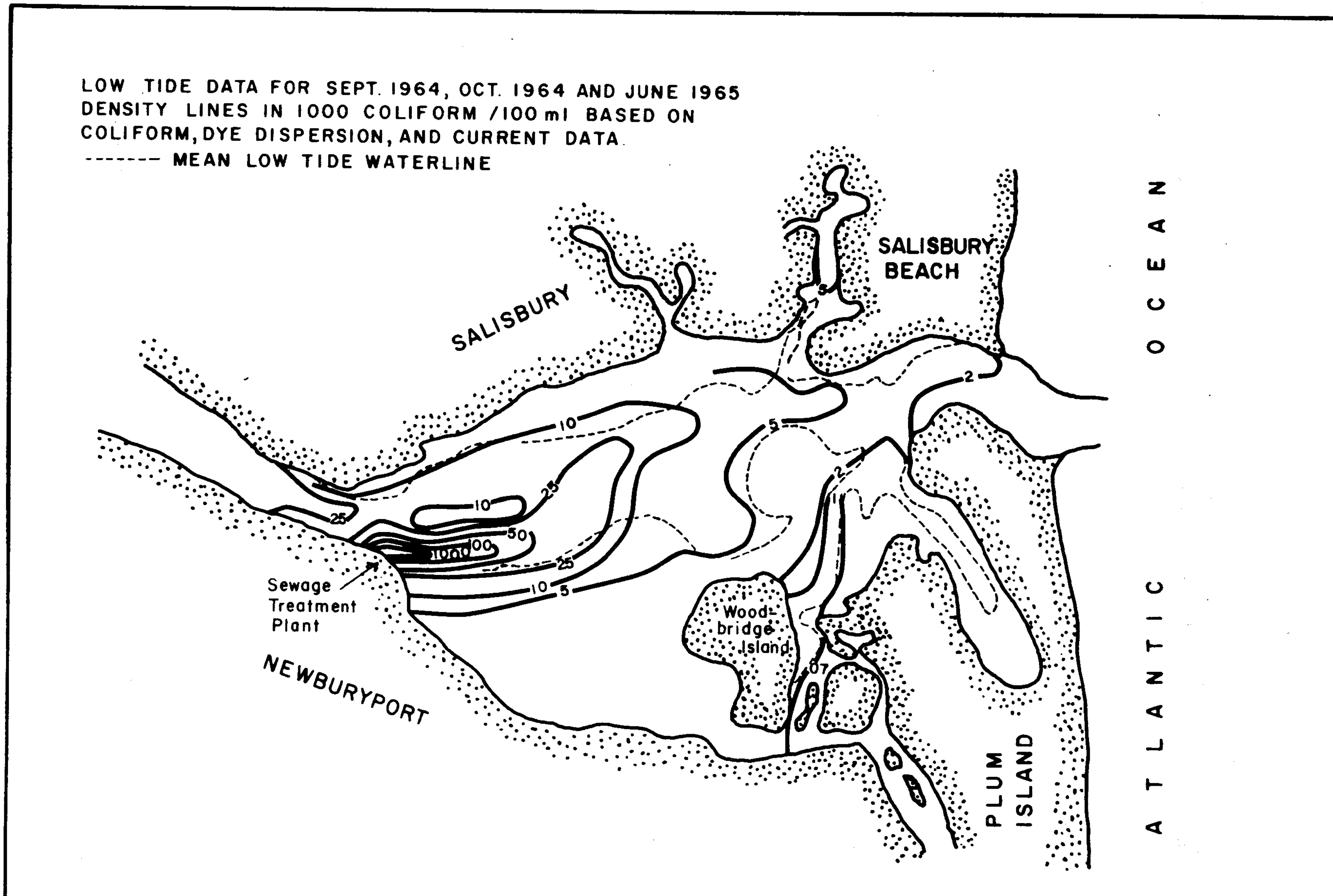
HIGH TIDE DATA FOR SEPT. 1964, OCT. 1964 AND JUNE 1965
DENSITY LINES IN 1000 COLIFORMS /100 ml
BASED ON COLIFORM, DYE DISPERSIONS, AND CURRENT DATA



TOTAL COLIFORMS IN MERRIMACK RIVER ESTUARY - HIGH TIDE

FIGURE B4

Figure B4
Courtesy FWPCA



TOTAL COLIFORMS IN MERRIMACK RIVER ESTUARY - LOW TIDE

FIGURE B5

Figure B5

3. AESTHETICS

a. Visual Attitudes and Response

The Merrimack River is a tremendously underused visual resource. The glib comment of the "cities turning their backs on the river" is alarmingly true. Visual and physical access to the River is generally restricted and very little riverfront development exists. There is very little evidence of use. Repeated visual surveys failed to observe more than a few individuals on or along the River. Subdivisions stopped short of the River edge, not even affording themselves a view. The fact that the River is a physical entity is only remotely recognized as highways, powerlines, agriculture, and urbanization in the proximity of the River fail to respond in any way to its presence, by capturing its view, providing access or echoing its alignment (Figure B6).

b. Potentials for Aesthetic Impact

The senses which are most frequently employed by man are sight, hearing and touch. Because of the nature of water, man is much more likely to use his sight first and then his sense of smell to determine aesthetic water quality; the senses of hearing, feeling and taste are of secondary importance. The sense of smell becomes of prime importance because man is not always able to judge the quality of a water body by sight alone, he must smell the body of water to determine if what appears to be clean actually smells clean.

Bio-stimulants (nutrients, i.e. nitrogen and phosphorus) can cause excessive algae blooms and a speed up of the process of eutrophication. This is unpleasant to see as well as to smell. Algal blooms change

Figure B6. The Unappreciated River

both the color and the surface quality of the water, as well as leaving a deposition of algal slime on objects projecting above the water and along the shoreline. People immediately associate algae with dirty water. An algal condition almost always make body contact sports far less pleasurable. Taste of drinking water can also be effected by an algal condition.

When dissolved oxygen drops below levels necessary to sustain aerobic conditions, odors from decaying plant and animal life and from the benthic deposits at the bottom of the River can be expected. This anaerobic condition also means that sport fishing with its related marina activities can no longer be considered a viable recreational activity as at least 5 ppm of D. O. are necessary to sustain the more desirable sport fish.

Suspended solids are also an indication of the quality of wastewater and are therefore usually associated with polluted water. When conditions permit, solids will settle out of the water creating deposits of sludge which not only do not feel good underfoot, but also give off obnoxious gases when they decompose.

Turbidity or clarity of water is another potential for water quality improvement. Muddy or turbid waters may be naturally polluted by soil erosion. Generally speaking, clarity of water is highly valued for two reasons. It permits the immediate assessment that this water is not polluted (although this may not necessarily be true) and also allows the viewer to observe bottom flora and fauna.

Color of water has a tremendous visual impact that may leave an instant negative or positive impact. Algae, other plankton organisms, and industrial effluent outfalls may severely discolor water because of metals, dyes and chemicals found in industrial discharge (Figure B7).

The water surface is affected by and reflects many natural elements, but it is also the bearer of floating materials which have both negative and positive aesthetic meaning. Floating wood when squared into timbers may well have a negative connotation while a piece of natural tree may have a positive meaning. Orange peels will be received differently than floating grass. The important factor in the aesthetic acceptance or rejection of these materials is whether it has been associated with human beings (Figure B8).

The potential for aesthetic impact of the water has been discussed. Associated potential of equal impact can be found in the related components of the River system. Described below in random sequence are several of the major riverscape potentials.

As the River bank is the predominant edge in the riverscape it has great importance, outside of the quality of the water itself it probably has the most importance. It's aesthetic impact is very much a product of its physical make up as to slope, material, and configuration. The River bank supports various vegetation types and is also the home and refuge to various birds and animals. Those birds who have a major portion of their diet as fish, such as the seagull and heron, are very active and provide strong visual interest as they go about their feeding. Their cries are excellent additions to the soundscape of the River.

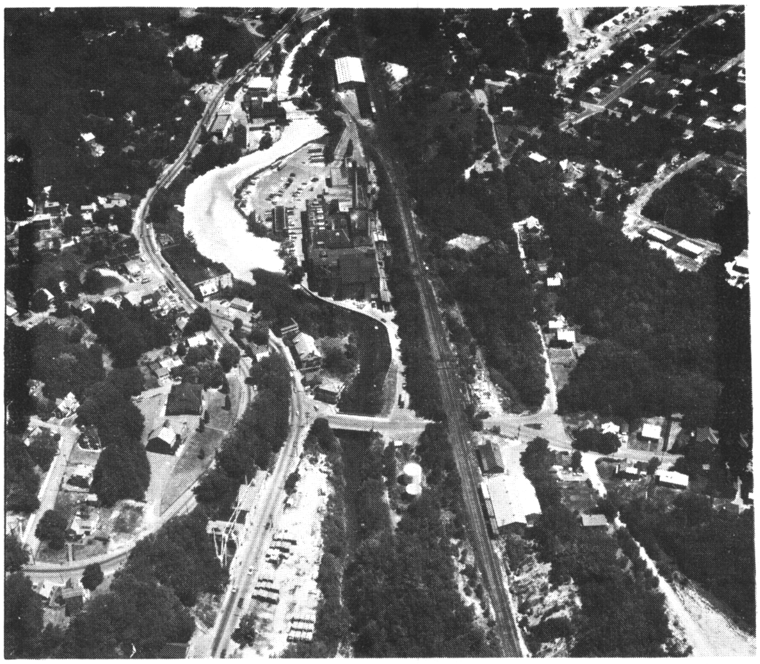


Figure B7. Industrial Discoloration

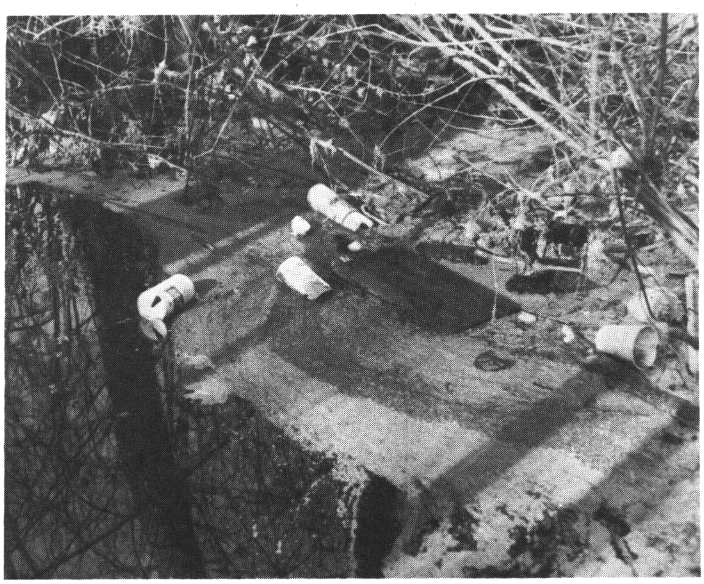


Figure B8. Water Surface Degradation

The River bed is one of the places that may be immediately noticeable as either a positive or negative river characteristic. If extensive mud flats are seen with decaying plant materials giving off unpleasant odors, or the bottom of the River has sludge deposits or a natural thick mud, the aesthetic impact will be a negative one. Mud flats exemplify a river with much less than its average flow, a condition which most people find disagreeable. Rocks mark the rise and fall of the water, now submerged, now with water rushing about them, and as an exposed piece of sculpture with the River providing the display area.

Alignment of the rivercourse assumes aesthetic importance on two levels, from a stationary observation position, and traveling along its length, either beside it or on it. From a stationary position the most pleasing river alignment is the one with the most visual contrast but with a well defined alignment. Edge configuration is therefore extremely important in the visual impact of the alignment of the River. A river with straight alignment but a highly varied edge configuration may have a higher visual quality than a river with a curvilinear alignment and a straight shoreline. Conversely the alignment with the greatest general aesthetic value would be the curvilinear with a highly varied edge configuration, while the alignment with the least general aesthetic value would be straight with a non-varying edge configuration. Besides curvilinear and straight, and all the intermediary alignments, there is a third one, braided. Because a braided stream is without a well defined edge or channel, it has a very low visual quality.

Ephemeral effects are those effects of a transitory nature. They are strong contributors to the deep aesthetic associations that people carry with them about riverscapes. Some passive recreators do seek out ephemeral effects as the focus of their recreation. Ephemeral effects consist of the play of the sun on the water: the reflections of the sun which come back to the viewer as bright flashes of light; the reflections of the sun off the water onto shoreline vegetation, the bank slopes, and the buildings bordering the stream; and the sun throwing the shadows of clouds, vegetation, land masses, and structures onto the surface of the water as well as the riverbed. The more elevated the viewer position the bluer the water will appear as it reflects the blue sky. Clouds as well can be reflected in the water as well as can vegetation and structures along the bank.

c. <u>The Merrimack Landscape</u>

A description of the River Basin landscape may be separated into two areas; the northern New Hampshire portion of the Basin and the southern New Hampshire-Massachusetts portion of the Basin, primarily below Nashua.

The upper Basin has a variation in topographic elevation change adjacent to the River. It varies from flat flood plain to steep banks on one or both sides of the River to occasional steep hills adjacent to the River. This modulation of topographically contained space is one of the most interesting aspects of the upper Basin (Figure B9).

Figure B9. The Upper Merrimack Basin

There are very few ponds or river width variations to provide visual interest at the macro scale. The width, alignment, vegetation type and height, and water surface and flow are very uniform at the larger scale.

Major portions of the upper River have the railroad directly adjacent to the River edge. This is often detrimental because of the excavation often needed for the railroads' roadbed and the reduction of visual physical access to the River.

The roads are generally several hundred yards from the River and do not respond to the alignment of the River, thus missing a visual interest opportunity; not affording many views of the River for the thousands of passing motorists.

The majority of the River edge, even in open land settings, contains a line of mature vegetation, thus softening the potential visual controls, and eliminating potential visual variation. This vegetation also stabilizes bank soils and thus avoids unsightly erosion.

The northern Basin has large tracts of uninterrupted forest land. Visual interest is reduced in those specific landscapes where the forest quality is not high and topography unvaried. Population density is low, the towns small, and major population areas directly adjacent to the River. For its entire length the River corridor contains the majority of urbanization, transportation routes and open land.

The lower Basin has more variation in river width, particularly in the Nashua River. The alignment of the old River is slightly more varied. The Nashua River exists in a relatively undeveloped natural corridor. This is not as true for the main stem Merrimack (Figure B10).

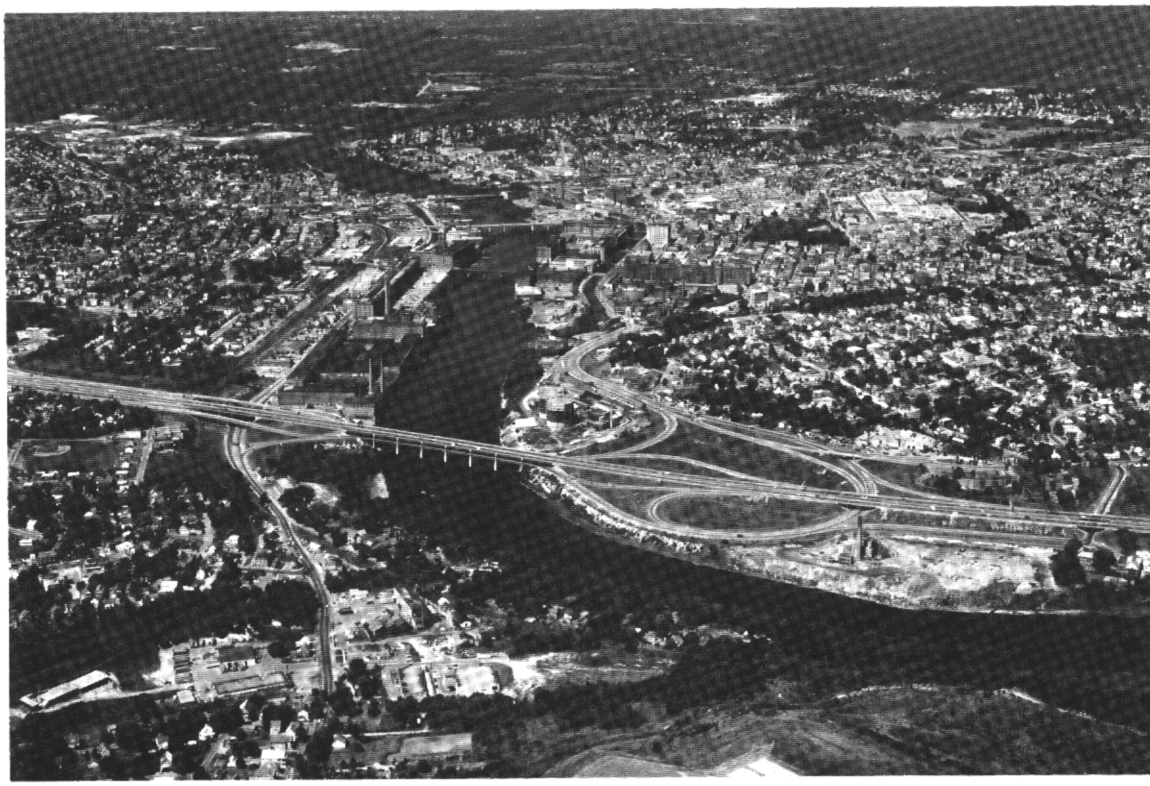


Figure B10. The Lower Merrimack Basin

Open land is somewhat more extensive in the Massachusetts portion of the Basin and is generally well distributed. It does, however, need to have additional open lands to maintain its quality under development pressures.

More urbanization exists in the southern Basin directly adjacent to the River. This structuring is more contrasting to the larger open space of the River and more contrasting to the materials of these structures.

d. The Merrimack Riverscape

The following riverscape summations are abstracted from a recent (July 1971) field survey of the River conducted by Walter Cudnohufsky, Landscape Architect and Environmental Consultant.

Winnipesaukee River

The River is a clear watercourse of from one to from one to four feet in depth with slow to quick movement. It has numerous exciting river falls, from riffles to waterfalls, as well as a large variety of sport fish. Generally, the Winnipesaukee River is of high aesthetic quality although it is still quite visually inaccessable.

Merrimack River from Franklin to and including Manchester

The color of the water in this section runs from clear to reddish brown with some spectacular color displays at some outfalls in urban centers, especially at Manchester. The River is slow and sluggish generally, although at specific points, fortunately mostly near urban centers, the River speeds up with dams and falls providing visual interest. Generally, because of uniform vegetation, sluggish flow, and a poor contextual landscape, the Merrimack from Franklin to and including Manchester is of poor to mediocre visual quality with some noted exceptions.

Merrimack From Manchester to and including Nashua

This section of the River is extremely similar to that immediately above Manchester. Perhaps the most unusual aspect of this River is the almost incredibly poor visual and physical access to it.

Generally, the Merrimack from Manchester to and including Nashua is of poor aesthetic quality with the land water contrast and its existence value as a water body being its two main positive points.

Merrimack - Nashua to and including Lawrence

This section for the most part is of medium visual quality on the large landscape contextual scale, but remains in poor aesthetic quality in the micro-scale due to poor bio-chemical characteristics. It has a strong aesthetic existence quality, with great potential as it is so close to an urbanized belt.

Nashua River

The clarity and color of the water in the Nashua has a wide range, with the generally applicable rule that where it passes through urbanized areas it is of low visual quality.

The Nashua River displays a wide range in the quality of both its micro-scale and its macro-scale from an aesthetic quality viewpoint. It can range from high to low aesthetic quality in a mile distance.

e. Baseline Conclusions

From the information provided so far in this assessment, the following statements can be made to guide the readers thoughts to potential areas for aesthetic impact.

- The River is both visually and biologically polluted below Manchester.
- Physical and visual access is limited along much of the River, especially intimate contact.
- The River is rather monotonous and needs visual excitement points at intervals along its length.

- Needs the addition of variety to as many of its easily controlled variables as possible.

- Functional uses and meaning must be ascribed to the Merrimack if the attendant visual use is to be increased.

- The elimination of open land must be stopped and additional open land created from woodland, especially on hillsides back from the River.

4. SOCIAL OPPORTUNITIES

In this part of the overall baseline of the Merrimack River Basin, the discussion will be by the impact categories presented in Table A2. In this way, it is hoped that the discussion will be logical and comp prehensive.

a. Land Use

In terms of land use the Merrimack River Basin is quite varied. In the Winnipesaukee River area to the north, there is a rural to semirural environment. As one moves to the south, the basin becomes increasingly urban, particularly along the river corridor. In the rural areas of New Hampshire and Massachusetts the major use of land is forest, generously called mixed New England hardwoods. Most of this could best be described as slash, of little or no value, economically, socially or aesthetically.

In the urban areas, riverfront areas are run down, dilapidated, and devoted primarily to industrial uses. Little of the frontage along the Merrimack River itself is devoted to recreational pursuits. Along the majority of the riverfornt, the river connot even be seen without diligently pursing that goal.

b. Population

The population pattern in the Merrimack River Basin are somewhat variable. The Standard Metropolitan Statistical Areas of Lowell, Lawrence, Haverhill, Fitchburg, and Leominster, are experiencing a period of out-migration due to the general economic decline in the textile and shoe industries. Population in these areas is growing rather slowly with Lowell leading the others slightly. Lawrence for example had a total out-migration of more than 4700 from 1960 to 1970. This is opposed to the rapid growth taking place just north of the New Hampshire-Massachusetts state line. Salem, New Hampshire, for example, grew by 118% from 1960 to 1970. This is explained in part by the difference in tax rates between New Hampshire and Massachusetts and also by the desire of people to move to a more rural environment. As one moves north in New Hampshire, the rapid population growth of the southern town disappears. People remain in the southern part due to the jobs in the Massachusetts communities. In addition, the rural areas of the basin have been experiencing an outmigration since World War II. This pattern seems to have been moderated in terms of total numbers because some people are returning to the rural areas to live while continudng to work in the urban areas.

The recreational areas of New Hampshire such as along the Winnipesaukee River area are experiencing a considerable seasonal immigration in population.

c. Leisure Opportunities

Water related leisure opportunities in the urban areas of Concord, Manchester, and Nashua, New Hampshire, and Fitchburg-Leominster and Lowell-Lawrence-Haverhill, Massachusetts, are severely lacking. All of the public bathing beaches on the Merrimack River were closed for reasons of public health before World War II. Boating areas exist on the river and the estuary but they are not used because of their lack of appeal. Sport Fishing is virtually non-existant along the Merrimack River and its tributaries, the Winnipesaukee and the Nashua.

The higher density cities also lack sufficient land based recreational areas. While these land areas exist are not to a large extent in the city but some distance away.

d. Municipal Services

Municipal services in the Merrimack River Basin vary greatly in quantity and quality. In general these vary with the size of the community. Water supply and sewage service are of prime concern when discussing the impact of wastewater management on social opportunity. Most communities in the basin have municipal water supplies. In terms of dependability of supply and quality of the supplied water, there is considerable variability. In several communities of the basin, i.e., Lawrence, water supply is currently taken from the polluted Merrimack River. Treatment costs are high and quality is highly variable. Some of the communities are reaching the limit of their available water supplies and are being forced to look for costly new surface and/or groundwater sources. The larger communities have sewer service but with little treatment.

e. Institutional Involvement

Government in New England is fragmented with the major burden being placed on the town. Cooperation between towns is rare with a sense of "you take care of your problem and I will take care of mine" prevailing. Even cooperation between local governments and higher jurisdiction is minimal and avoided where possible. Until recent years cooperation between states was almost unheard of. Now there are precedents established such as the New England Regional Commission and the New England River Basins Commission. These are a step in the right direction, but as yet cooperation between the smaller units of government is lacking.

f. Community Image

The communities of the Merrimack River Basin have little appreciation of or concern for the river that gave them their birth. The dwellers of these communities have little sensitivity for the Merrimack at all, save perhaps in the olfactory sense during low-flow periods. The degradation of its waters has been so complete and of such long standing that the native population has ceased to except anything of it whatsoever except, perhaps, that it be kept as for away as possible.

As in other communities across the nation, the communities of the Merrimack River Basin are proud of their accomplishments and take pride in themselves. In doing so the river is hidden behind factories and vegetation so as not to detract from the image the community puts forth.

5. ECONOMICS

a. General Economic Profile

The Merrimack River Basin consists of a major portion of New Hampshire, over half of the state, and a much smaller portion of eastern Massachusetts stretching into the outskirts of Greater Boston. Consequently the Basin includes areas of quite diverse economic activity. The northern portion is quite undeveloped; the middle section including Lake Winnipesaukee is primarily recreational; the southern section, commencing with Concord-Manchester, is increasingly industrial.

Table B8 presents some salient statistics for the Basin. Given the wide diversity within the Basin, these statistics must be further analyzed by by sub-regions to yield a meaningful profile of the area.

Table B8

SALIENT STATISTICS OF THE MERRIMACK RIVER BASIN

	1960	1970	1990	2020
Population (1000's)	1,081	1,250	1,452	1,872
Personal Income (per capita)	2,951	5,078	8,089	12,842
Relative to U. S.	1.36	1.23	1.27	1.19
Employment (1000's)*	994	1,004	1,235	1,842
% in primary (agriculture)	1.6	1.2	.6	.3
% in secondary (manufacturing)	33.6	31.7	28.2	23.5
% in tertiary (services)	64.8	67.1	71.2	76.2

*Employment estimates seem to be based on totals for economic areas which go beyond Basin boundaries.

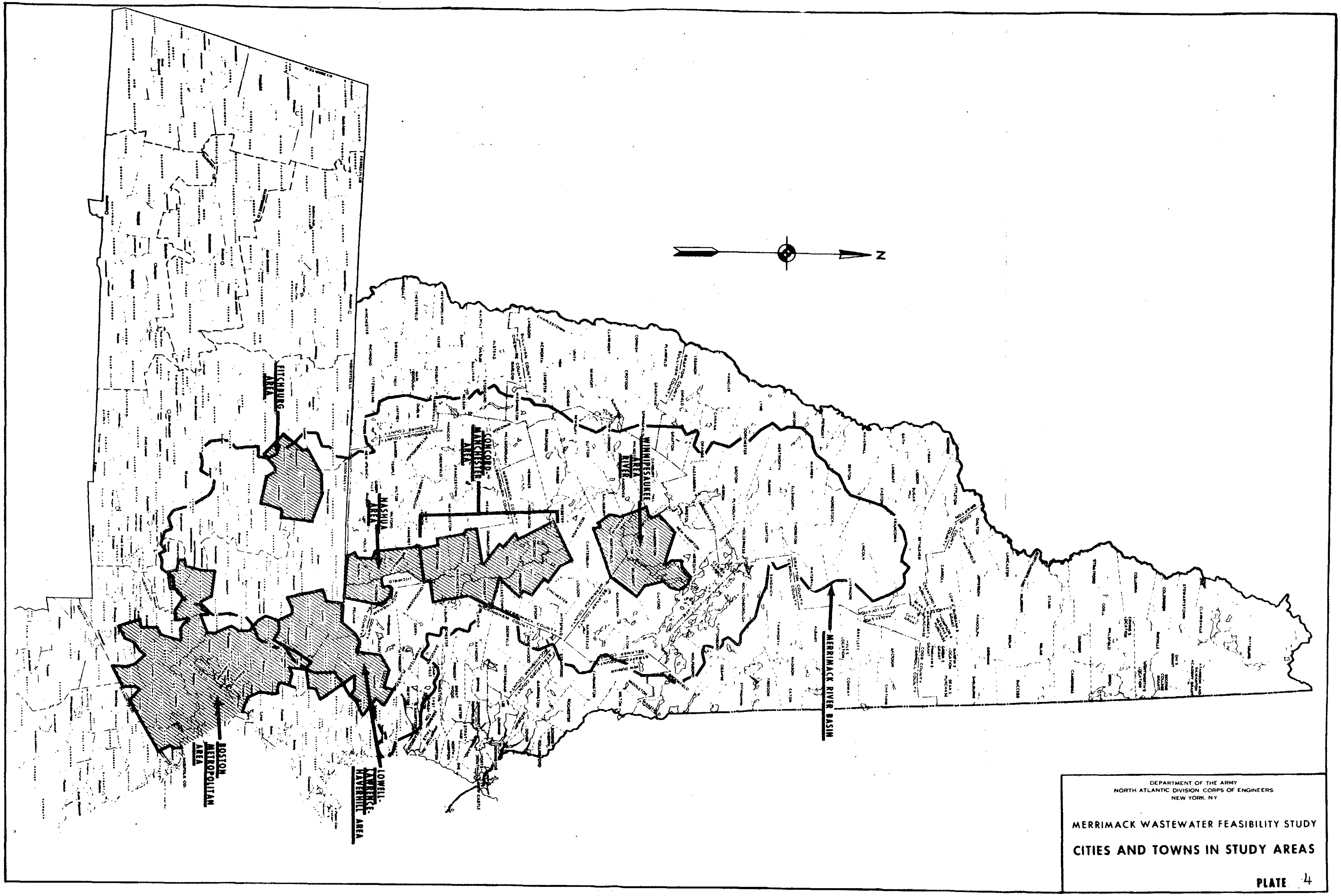
Plate 4 indicates the regional breakdown chosen for this analysis. Since economic data is available by county rather than by basin designation, most of the analysis is confined to county data for the portions of the Basin lying in New Hampshire and to data on SMSA's (Standard Metropolitan Statistical Areas) lying in the Massachusetts section. In this way roughly 90% of the land area and the population in New Hampshire, and about 40% of the population and area of the Basin lying in Massachusetts can be accounted for. The actual breakdown is given in Table B9 which also presents population estimates for the areas covered. A part of Grafton County falls outside the Merrimack Basin, as do very small portions of Belknap and Merrimack counties.

Table B9

SUBREGION ECONOMIC INDICATORS, 1960

Subregions	Population Density per sq. mile	Employment Mfg./Total	Population (thousanths)
New Hampshire	67	39.7	606.9
Grafton	28	26.3	48.9
Belknap	72	37.7	28.9
Merrimack	73	31.5	67.8
Hillsborough	199	43.9	178.2
Massachusetts			
Fitchburg-Leominster	540	50.7	90.2
Lowell	1,081	42.1	164.2
Lawrence-Haverhill	957	47.7	199.2

Source: County and City Data Book, 1967.



DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION CORPS OF ENGINEERS
NEW YORK, NY

MERRIMACK WASTEWATER FEASIBILITY STUDY

CITIES AND TOWNS IN STUDY AREAS

PLATE 4

The economic composition of the counties changes gradually north to south (Table B9). Population becomes more dense, and the ratio of manufacturing employment to total employment rises. A number of other indices indicate the same trend toward urbanization in the southern reaches of the Basin. These will be treated in the discussion of the New Hampshire agricultural sector below.

At present there are two major cities, Lowell and Lawrence, that are using the Merrimack River as a source of municipal water supply. Since 1963 the river has been the principal source of water supply for approximately 65,000 persons in the City of Lowell, Massachusetts. Lowell's water intake is located eleven miles below Nashua, New Hampshire, and seven miles below the New Hampshire-Massachusetts state line. Lawrence, Massachusetts, which has been using the Merrimack as a source since 1893, is presently supplying water to 90,000 people in Lawrence and neighboring Methuen. The water intake is located nine miles downstream form Lowell.

As populations rapidly increase in many of the cities and towns along the Merrimack River, additional municipalities may need to use this convenient source of water supply. Chelsford, Tyngsboro, Andover, North Andover, Tewksbury and West Newbury, Massachusetts, have already been mentioned as potential users of the Merrimack, not to mention Concord, Manchester and Nashua, New Hampshire.

In addition, several tributaries are now being used. Billerica, Massachusetts, uses the Concord River as its source of municipal water supply, having completed a new water treatment plan for this purpose in 1955.

Nashua, New Hampshire, utilizes part of the flow of the Souhegan River. Additional use of tributaries is being considered by several cities and towns. These include Burlington, Massachusetts, (the Shawsheen River) and Concord, New Hampshire, (the Contoocook River).

b. Agriculture

Merrimack River water is used for irrigation of truck crops from Franklin, New Hampshire, to below Haverhill, Massachusetts. Between Manchester, New Hampshire, and the state line, there are several hundred acres of truck crops along the banks of the Merrimack River.

New Hampshire agriculture has been declining steadily in post-war years. From 1950 to 1964, the number of farms fell from 12,500 to 3,650, through a good part of this decline represented the consolidation of farm lands into larger and more efficient holdings. Nevertheless, in 1964 the average size of farm amounted to about 200 acres (half the U.S. average) with about half of all farms with less than 100 acre plots. Unlike farms in other areas of the country, much farmland in the area includes forests as well as open fields. Harvested area or area used for pasture accounts for perhaps 30% of farm holdings.

Agricultural output in New Hampshire also fell absolutely from 1950 to 1964, by about 15%. Acreage used fell accordingly. The decline has, moreover, affected virtually all branches of agriculture, including livestock, hay, vegetable, fruit, dairy and forest products output. Some salient farming statistics are included in Table B10.

While the exact reasons for the decline are not easy to pinpoint, several factors bear mention. Perhaps the most important among these is the geography of the New Hampshire area. About 85% of the land in the state is wild forest land, difficult to reclaim, and quite often unsuitable for cropping. Much of the remainder consists of rocky, uneven terrain which has not stood up to mechanization as have the soils of competing agricultural states. The climate itself is relatively unfavorable; there is about one month difference in frost free period between the southern and northern portions of the state, and the growing season from Belknap county northward lasts only 120 days.

The second major reason for the decline of agriculture is the slow encroachment of industrialization spreading northward from the Boston Metropolitan complex. This effect acts in several different ways. First, is the direct effect of industrial land demand. Second, the potential for employment in industry has created a serious shortage in farm labor. Third, recreational demand for land with the southern cities as the chief source has exerted a powerful upward pressure on land values. Table B11 indicates the average value of land and buildings per acre. Unfortunately, it is impossible to separate out land values, but the trends are quite clear.

Table B10

SALIENT STATISTICS OF AGRICULTURE IN FOUR

NEW HAMPSHIRE COUNTIES

	Grafton	Belknap	Merrimack	Hillsborough
No. Farms, 1964	699	266	611	617
1969	990	359	903	1,000
Land in Farm (1000 acres)				
1964	183.1	49.7	115.4	100.0
1959	226.4	62.7	157.1	144.0
Land Use (100 acres)1964				
Cropland, harvested	29.9	9.0	19.4	20.5
Cropland, pasture	12.1	2.0	8.6	7.2
Woodland, pasture	31.7	6.3	13.0	5.0
Woodland, not pastured	95.4	25.6	61.5	53.1

Source: Census of Agriculture

Table B11

AVERAGE VALUE OF LAND AND BUILDINGS

PER FARM ACREAGE, 1964

New Hampshire	$ 132.12
Grafton County	77.87
Belknap County	136.23
Merrimack County	122.93
Hillsborough County	200.33

Source: Census of Agriculture

A third reason for the decline of New Hampshire farming can be found in the changes experienced by the agriculture industry in general. Transportation networks and technologies connecting the population centers with the producing areas have improved considerably, and the comparative advantage of the Northeast as a supplier has declined accordingly. The advances referred to here also include shifts in the vertical structure of the agriculture industry; many more products reach the consumer in processed (frozen, canned, etc.) form than, say in 1950.

A fourth reason can be traced to the land conditions of the area. The nature of the topography has segmented farmlands to the extent that average holdings are nearly one-half of U.S. averages. This factor, reinforced by the age of the agriculture industry in the area, has resulted in small-scale, and necessarily less efficient farming at levels below those required for achieving competitive economies of scale. Table B12 presents the present breakdown of agricultural production in the counties included in the present study.

TABLE B12

AGRICULTURAL PRODUCTION IN FOUR

NEW HAMPSHIRE COUNTIES, 1964

	Grafton	Belknap	Merrimack	Hillsborough
Crops ($1000)	619.1	344.8	887.6	2,103.9
Vegetables	21.8	16.5	95.2	552.6
Fruits & Nuts	85.9	199.7	232.9	976.2
Forest Products	346.7	93.2	344.0	403.4
Field Crops, other	164.7	35.4	215.5	171.7
Livestock ($1000)	5,001.5	1,490.0	4,966.2	8,081.5
Poultry	577.4	578.9	1,963.8	4,871.7
Dairy	3,793.0	831.2	2,500.4	2,723.7
Nes.	630.9	79.9	502.1	486.2

Source: Census of Agriculture

As is quite evident from Table B12, poultry farms and dairy farms account for most of the agricultural production in the counties studied. Fruits and nuts show as a poor third, with vegetables and forest products in last place with roughly equal amounts. Poultry products and dairy products appear prominent primarily because of the closeness of the city markets; in addition, poultry farming represents an intensive form of agriculture well suited to the southern reaches of the Basin.

c. Projections for Agriculture

As the foregoing indicates, the agriculture industry in New Hampshire faces rather severe obstacles to development. The factors which have accounted for the shrinkage during the past decade are likely to intensify. Encroaching urbanization and industrialization is likely to further increase land values (and taxes), and to offer employment alternatives to potential farm labor. In addition, the southern and central portions of the region have experienced heavy land demand for recreational purposes. In Belknap county, for example, nearly 40% of structures are used seasonally by owners from the southern cities.

On the other hand, the competition fostered by the shrinking industry has served to solidify the surviving segments. Accordingly, farm size and capital have grown steadily, allowing for increasing utilization of modern labor-saving equipment. This development, some experts feel, will tend to slow the level of decline of the industry, particularly in dairy production.

According to the Cooperative Extension Service at the University of New Hampshire, the number of cows is likely to decline from about 36,000 in 1970 to about 30,000 in 1980. The consolidation of farms within the industry is likely to continue during the next decade, with herds continually increasing in size. The average size by 1980 is expected to increase from 46 to 83.

Similarly concise forecasts for other branches of the agriculture industry in New Hampshire have not been located. On the basis of qualitative information and discussions with experts, it is estimated that poultry production is likely to maintain at least 1963 levels throughout the 1970-1980 decade, while fruits and vegetable production should decrease by about 25% during the period. These estimates are extremely rough, and further refinements are necessary before they are used in final form.

One economic area in the Basin showing significant recent increases is the production of red meats; beef and pork. This trend, caused partly by increases in demand during the late 60's, has not yet stood the test of longer periods of competition. Possible increases in this area may well compensate the livestock losses that are expected to take place in dairy production.

d. Manufacturing

Manufacturing employment has risen steadily in both the New Hampshire and Massachusetts portions of the Basin. Increases were made in the New Hampshire segment by food products, chemicals, plastics, etc., by primary metals, and by industries related to the use of lumber, paper and wood products. A general decline has hit the textile and leather industries over the entire Basin, with the Lowell area feeling the effects most strongly. The Massachusetts portions have seen a particularly rapid increase in the electronics, chemical, and metal products associated with the famous Route 128 complex in southern portions of the Basin. The electronics activities have experienced severe cutbacks in the past year, and their future development is less optimistic today than forecasts in the mid-60's indicated. The machinery production throughout the region can expect a relatively optimistic future. Statistics concerning industrial establishments with over twenty employees are given in Table B13. Office of Business Economics projections for two areas, (a) the Manchester area which includes all of the New Hampshire portions of the Basin and some other counties in New Hampshire, and (b) for the Boston Water Region area which includes Eastern Massachusetts and Rhode Island are also presented as a guideline for the industrial outlook of the region (Tables B14 and B15.

As the OBE data indicate, future increases are likely in manufactures in the Basin. The particular composition of the increases is not known; OBE in particular projected future employment only for a few sectors which are rather poorly represented in the region under study. But it is likely that the lumber-related industries will continue to develop, though forest production may be quite independent to the extent that import potential from Maine and Canada is significant.

TABLE B13 - STATISTICS CONCERNING MANUFACTURING ESTABLISHMENTS WITH OVER 20 EMPLOYEES, 1963

Statistics	MASSACHUSETTS			NEW HAMPSHIRE			
	Fitchburg-Leominster SMSA	Lawrence-Haverhill SMSA	Lowell SMSA	Belknap County	Grafton County	Hillsborough County	Merrimack County
All Employees, Ann. Aug (No.)	17485	42020	21120	3635	4581	34679	7678
Payroll, Entire Yr ($1000)	92082	214286	102594	17149	19421	159166	35339
Production Workers, Ann. Aug	13797	30629	16630	2922	3963	27516	6532
Man-Hours (1000)	28535	58626	32235	6312	8348	53433	13003
Wages, Entire Yr ($1000)	64882	132854	69367	12879	15083	110221	26279
Value Added ($1000)	167851	365306	168649	27750	28545	258455	64082
Capital Expend., new ($1000)	14476	16276	5871	1049	1487	10386	4385
All Employees, Ann. Aug (No.)	16976	36378	19104	3698	4195	32533	5923
Value Added ($1000)	126072	268186	115353	25178	24395	189738	35773
Total Establishments	289	476	298	85	117	449	169
Total w/x 20 Employees	123	193	136	27	34	201	64
w/20	NA	NA	NA	17	22	120	42
w/100	NA	NA	NA	10	12	82	21

Numbers of Establishments of Selected Industries

Food and Tobacco Prod.	8	17	12	2	--	20	4
Textile, Apparel & Leather Prod.	17	95	63	10	11	65	17
Paper & Printing	14	16	15	2	8	13	12
Chem.,Oil, Rubber & Plastics Prod.	34	16	11	-	1	11	1
Lumber, Wood Prod. & Furniture	9	10	4	3	5	27	10
Stone, Clay & Glass Prod.	-	2	4	1	2	8	2
Prim & Entermed Metal Prod.	8	9	9	2	2	17	6
Elec & Nonelec Machinery	15	20	12	4	4	30	11
Transp & Ordnance (incl. Missiles)	2	-	1	-	-	-	1
Instruments & Misc. Prod.	14	3	2	3	1	7	11

Source: U.S. Bureau of Census, County and City Data Book, 1967 (A Statistical Abstract Supplement). U.S. Government Printing Office, Washington, D. C., 1967.

TABLE B14 - POPULATION, PERSONAL INCOME AND EARNINGS, PROJECTED FOR SELECTED YEARS, 1970-2020

Manchester, N. H., Water Resources Planning Area
(Belknap, Carroll, Hillsborough, Merrimack, Rockingham, and Strafford Counties.)

	1970	1980	1990	2000	2010	2020
Population	511,100	581,300	678,300	774,000	891,600	1,020,600
Total Personal Income (000-$58)*	1,567,831	2,390,135	3,625,968	5,542,560	8,440,926	12,666,187
Per Capita Income ($58)**	3,067	4,111	5,346	7,161	9,467	12,411
Per Capita Relative (US=1.00)	1.01	1.00	1.00	1.00	1.00	1.00
Total Earnings (000-$58)*	1,217,141	1,830,145	2,726,590	4,103,269	6,164,722	9,144,572
Per Worker Earnings ($58)**	5,824	7,544	9,877	12,945	17,153	22,572
Per Worker Relative (US=1.00)	.92	.93	.95	.95	.96	.97

Employment by Selected Industries, 1970-2020

	1970	1980	1990	2000	2010	2020
Population	511,100	581,300	678,300	774,000	891,600	1,020,600
Total Employment	209,000	242,600	276,100	317,000	359,400	405,100
Participation Rate (Empl/Pop)	.41	.42	.41	.41	.40	.40
Agriculture Forestry + Fisheries	3,700	2,900	2,400	2,000	1,700	1,400
Mining	D	D	D	D	D	D
Manufacturing	78,100	83,900	90,100	96,400	102,700	109,600
Food + Kindred Products	2,600	2,600	2,500	2,600	2,600	2,700
Textile Mill Products	7,800	6,800	6,100	5,400	4,800	4,300
Chemicals + Allied Products	500	700	800	1,000	1,200	1,400
Paper + Allied Products	2,200	2,200	2,100	2,200	2,200	2.100
Petroleum Refining	D	D	D	D	D	D
Primary Metals	1,400	1,500	1,700	1,800	2,000	2,100
Armed Forces	5,500	5,300	5,300	5,300	5,300	5,300
Other	121,600	150.400	178,300	213,200	249,600	288,800

*Including Armed Forces Pay
**Computed from unrounded data
D Too small to be projected but included in higher level totals

Source: Office of Business Economics Projection

TABLE B15 - POPULATION, PERSONAL INCOME, EARNINGS AND EMPLOYMENT
HISTORICAL AND PROJECTED FOR SELECTED YEARS

North Atlantic Hydrologic Sub-Area
[Including Belknap, Merrimack and Hillsborough Counties (New Hampshire), and Worcester and Middlesex Counties (Massachusetts)]

	1959	1960	1980	2000	2020
Population	2,080,579	2,095,731	2,570,800	3,212,800	3,976,000
Total Personal Income (000-$58)*	4,994,795		11,611,100	24,854,900	52,904,800
Per Capita Income ($58)**	2,401		4,517	7,736	13,306
Per Capita Relative (US=1.00)	1,125		1,098	1,080	1,072
Total Earnings (000-$58)*	4,039,794		9,169,400	19,286,400	40,544,300
Per Worker Earnings ($58)**	4,876		8,641	14,594	25,063
Per Worker Relative (US=1.00)	1,045		1,069	1,072	1,073
Population	2,080,579	2,095,731	2,570,800	3,212,800	3,976,000
Total Employment	828,576	835,039	1,061,100	1,321,500	1,617,700
Participation Rate (Empl/Pop)	.398	.398	.413	.411	.407
Employment by Selected Industries					
Agriculture Forestry + Fisheries		10,822	7,800	6,000	4,500
Mining		618	300	200	200
Manufacturing		321,326	336,400	365,000	396,600
Food + Kindred Products		21,138	16,700	14,700	13,800
Textile Mill Products		27,021	15,400	10,900	8,000
Chemicals + Allied Products		7,002	9,000	11,000	13,100
Paper + Allied Products		14,451	16,400	18,500	20,300
Petroleum Refining		1,281	500	300	100
Primary Metals		12,420	15,100	17,100	18,900
Armed Forces		14,631	11,500	11,500	11,500
Other		484,684	702,400	934,500	1,199,100

*Including Armed Forces Pay
**Computed from unrounded data
D Too small to be projected but included in higher level totals

Source: Office of Business Economics Projection

In addition, the rubber and related plastic products are likely to show significant development. The outlook for electronics is not clear at the present time, depending on the course of military and space expenditures during the next decade.

The labor markets of the area are quite good from a number of different viewpoints. Technical personnel is available from the Greater Boston complex of universities. Unskilled labor is also in abundance in the Route 495 belt stretching across the Massachusetts SMSA's under study. If a shortage exists, it is likely to be in the area of skilled machine operators.

Industries requiring technical personnel would find the Basin area quite attractive. Living conditions and ample recreation opportunities make the area quite attractive, and the urban developments are still sufficiently separated to provide relatively inexpensive housing for employees. The proximity of Boston is also a possible advantage. Transportation facilities are good in terms of road networks, though rail transportation is inadequate for long distance shipping of any significance.

About half of industrial water use is for cooling purposes, which requires no processing. Some industries do use Merrimack River water for processing, but the water quality is not satisfactory and sand filters are needed to precondition it. Feeder streams are also used for industrial water supplies. Nashua River water is used for industrial processing in a number of instances. Where preconditioning is necessary, facilities ranging from sand filters to ion exchange processes are used.

The Merrimack River is used for hydroelectric power to some extent. On the Merrimack below Franklin, New Hampshire, there are five utility plants and thirteen privately-owned industrial developments, with total capacities of 28,670 and 22,320 kilowatts, respectively. These 18 plants utilize 177 feet of a total fall of 254 feet. Canal systems at Lowell and Lawrence, Massachusetts, divide the use of water among several plants at each location. On weekends, the Merrimack River flow below several of the dams is drastically reduced as a result of "stacking" practices. This two-day reduction in flow seriously affects the capacity of the river to assimilate wastes during July, August and September.

Data is not immediately available concerning the probable future development of hydroelectric power generation in the Merrimack basin. This point should receive closer scrutiny in future studies.

e. Service and Population-Related Industries

This branch of the regional economy consists of activities whose level depends, in some way, on the population and income of the region, rather than on its natural resources directly. Trade, construction and transportation are included, as well as government, finances, and the entire spectrum of personal and business-related services. Despite the enormous economic significance of this sector, which employed two out of three workers in the Basin in 1970, there is a woeful lack of data concerning the direct and indirect relationships between this sector and other branches of the regional economy. Clearly, the structure of services employment (and the income it generates) are not independent of the detailed nature of the regional economy. At present, however, only gross aggregates of present and projected services employment are available, an inadequate state of affairs which needs to be corrected in future studies.

f. Recreation and Tourism

Water-oriented recreational activity has been increasing swiftly in the United States, especially near major centers of population. Comparable growth in the Merrimack River Basin, however, has been frustrated by its polluted condition.

The Merrimack River is used for boating and water skiing above Manchester, Lowell and Lawrence, and in the tidewater near its mouth. Ski clubs have been formed by people with this mutual interest, and ski jumps are provided for members. For the past several years, the Eastern Stock Outboard Boat Racing Championships have been held in the Merrimack River above Lowell. Other races have taken place in Haverhill and Lowell since the mid-1950's, indicating the popularity of the River for boating. In the Nashua River, there is a small amount of boating in the reservoir above Pepperell; the Concord River is utilized for this purpose in Billerica and Concord.

For several years, Lowell provided a public bathing beach and a change house along the Merrimack, upstream of the city. This facility was closed in 1965 due to pollution. No other public bathing facilities exist on the Merrimack River at this time, although the City of Concord, New Hampshire, has considered converting the present Sewells Falls power generating station and surrounding land to a recreational area.

Swimming takes place to a limited degree at several other points on the River, notably at Hooksett and Manchester, New Hampshire, and Tyngsboro, Lowell, Lawrence and Newburyport, Massachusetts.

Water-oriented recreation is an attraction for tourism as well as use by Basin residents. Moreover, many of the scenic and historic tourist attractions of the Basin are found in association with bodies of water.

Considering that the Northeastern states have 25 percent of the population of the country but only 4 percent of its recreational acreage, providing reasonable access to the out-of-doors for large concentrations of population will become one of the Northeast's central problems in the next forty years. At the center of concern will be the day and week-end needs of metropolitan residents. With some 10.5 million people within an easy day's drive of the Merrimack River, and an additional 6.5 million expected by the year 2000, the need is easily recognized.

Recent statistics indicate that 41 per cent of the population prefers water-based recreational activities, and it is conservatively estimated that it spends $8.00 per person per day for food, lodging, transportation and miscellaneous items.

More detailed information and projections concerning recreation and tourism in the Merrimack Basin are not presently available, but such information could probably be assembled without unreasonable difficulty, and should be included in future studies.

g. Fish and Wildlife

According to the U.S. Fish and Wildlife Service, parts of the Merrimack River in New Hampshire possess an outstanding fishery. However, there is public aversion to using fish caught from the River for food because of the raw sewage emptied into the River. Consequently, any fishing done there is merely for sport. Rainbow and brook trout are planted in approximately 155 New Hampshire rivers and brooks that are tributary to the Merrimack River, excluding tributaries of Lake Winnipesaukee.

The Merrimack River, between the Nashua River and the state line, contains the following fish species in large numbers: yellow perch, red-breasted sunfish, pumpkinseed, large-mouthed bass, eastern chain pickerel, northern common bullhead, eastern golden shiner, eastern common shiner, fallfish, long-nosed dace, eastern black-nosed dace and eastern common sucker.

The Commonwealth of Massachusetts has estimated that sport fishermen spent over $1,000,000 in total expenses while fishing in the Merrimack River Estuary in 1964. The value of an industry of this magnitude to the cities and towns in the vicinity of the Merrimack River Estuary is obviously tremendous. However, the polluted condition of the River prevents this revenue source from reaching its maximum benefit to the local communities. This sport industry is primarily dependent upon striped bass, mackerel and blackback flounder fisheries and offshore ground fishery.

Commercial fisheries existed for only three species of fish in 1964. Approximately 178,000 pounds of striped bass were sold for about $44,500 in that year. One of the other important fisheries is that for American Sand Lance or Sand Eels for use as food and as bait. Approximately 1,400 barrels of these fish worth $14,000 were captured in 1964. Also in 1964 about 3,000 pounds of American Eels were taken from the Merrimack for use as food and bait. This catch of eels was worth about $500. It is a significant commentary on the present state of the commercial fishery in this Estuary, which once teemed with valuable fish, that its products were in 1964 only worth a total of $78,000 for a whole year's effort.

Prior to construction of the dams on the lower Merrimack, hundreds of thousands of anadromous fish were caught annually in the Merrimack River. The most important species included salmon, shad, ale-wives and smelt. The Merrimack River, once famous for its salmon run, hasn't seen a salmon in almost fifty years. Their disappearance is attributed mainly to dams and pollution.

According to the U.S. Fish and Wildlife Service, the present shad run into the Merrimack is small, because the only area available for spawning, the lower section of the River, is heavily polluted. Even through the fish can ascend the fishway in the Essex Dam at Lawrence, they can only proceed upstream to the Pawtucket Dam at Lowell, which is completely impassable. The number of shad annually ascending the Lawrence fishway is from 1,500 to 3,000 fish. Fishing for shad in the lower River is sporadic, and in some years there is none at all. In 1960 no fish were reported taken.

Because of the polluted conditions in the Nashua River, it is not used for fishing, although it is populated by various types of coarse fish in the lower section.

The most common macroscopic invertebrate in the estuary is the softshell clam. Associated with the softshell clam is the clam worm, the blood worm, the duck clam, and the blue mussel. Since 1926 the shellfish beds in the Estuary of the Merrimack River have been closed to harvest. In certain small sections shellfish can be taken and treated in the shellfish depuration plant at Newburyport. Due to gross pollution, largely as the result of sewage discharged to the river by neighboring communities, the commerical value of the soft shell clam was only $14,000 of a potential $1,000,000 harvest in 1964.

The Plum Island marshes and waters of the Merrimack Estuary are renowned for the concentrations of marsh birds, shore birds and waterfowl that are found there. Gunning for waterfowl has been practiced there since colonial times. In recent years it has been a favorite spot for bird-watchers and students of ornithology. These waterfowl populations constitute approximately eight percent of the Commonwealth of Massachusetts coastal waterfowl wintering populations. The major species inhabiting the marshes and bays of the Estuary include geese, sea ducks, dabbling ducks, and diving ducks.

Extensive areas of excellent nesting habitat for marsh birds and some waterfowl species exist despite the encroachment of man. Thousands of ducks and geese winter in the area, but the largest numbers of birds are present during spring and fall migrations when flights of ducks and geese are passing through and hordes of sandpipers and plovers scour the tidal flats feeding on tiny marine organisms.

The present level of pollution in the Merrimack River has had little direct effect on these groups of birds although it has affected many of the animals and plants upon which they feed. The survival of fish and shellfish larvae has been reduced in the areas of heavy pollution in the River whereas some of the pollutants have served to nutrify the marshes around the river mouth. There is no data at hand dealing with the economic significance of hunting activity, for nearby communities, but it probably could be easily obtained in future studies. It might be expected to be of the same order of magnitude, on a per-person basis, as is the case for sport fishing.

h. Visual and Cultural Environment

Because considerations of this description are highly subjective, dealing as they do with the role of a pleasant environment in the overall quality of life, they are almost impossible to deal with in a quantitative way. For the same reason, however, this area of inquiry has enormously important implications for all phases of water resources planning, including economics. Alleviation of water pollution works a direct improvement on the visual and cultural environment, which is generally considered desirable of itself: grossly polluted water is noisome and ugly. In addition an increase in the aesthetic quality of a stream is reflected by increases in tourism and water-oriented recreation, enhanced property values and tax revenues, and possible effects on industrial and population location.

Although detailed information is not available, it is clear that portions of the River are aesthetically degraded. Restrictions on the development of water-oriented recreation have already been noted; loss of locally-received related income and tax revenues are almost certainly experienced as well. Increasing population, and increasing urbanization, can be expected in the future to multiply the demand for aesthetically adequate recreational opportunities. Since the absence of crowding is an important element in such an experience (crowds and overdevelopment being what recreation patrons are seeking respite from), it is evident that, *cetaris paribus*, the relative scarcity of clean, pleasant water vistas and recreation sites will worsen considerably.

CHAPTER C - THE IMPACT OF SOLUTIONS

1. CURRENT EPA STATE WASTEWATER TREATMENT PROGRAM

To comply with standards established by the states of New Hampshire and Massachusetts, EPA has stated that universal secondary treatment must be implemented throughout the Merrimack River Basin by 1975. (See Appendix III for a detailed discussion). This degree of wastewater treatment will have certain impacts upon the basin. The following discussion will examine the ecologic, hygienic, aesthetic, social, and economic impacts.

a. Ecologic

The implementation of secondary treatment for the entire Merrimack River Basin will have little impact on the overall terrestrial environment of the region. Any impacts will be site specific and limited to the sites of treatment plants and the immediately surrounding areas. The site of a treatment plant will be similar to that of an industrial plant except that attempts are usually made to conceal sewage treatment plants.

The ecologic impact of universal secondary treatment on the aquatic communities of the Merrimack River Basin will be considerably more profound than the impact on the terrestrial communities of the region. Secondary treatment will remove the load of suspended and dissolved organic oxygen demanding wastes upon the rivers, which will lessen the turbidity levels.

High levels of nitrogen and phosphorus in the water will continue and likely increase with increase with increasing population in the region. In the secondary treatment process, wastewater is retained in clarifiers, offering a probable temperature rise in discharges, at least during the critical summer months.

The removal of the load of oxygen demanding wastes on the stream will result in higher levels of dissolved oxygen but this could be offset by biological breakdown of algae growth where they occur.

There should be an increase in the species diversity of benthic organisms due to the reduction in noxious sediments. Fish communities in some parts of the river will become more diversified. For a more detailed analysis, see Annex B.

Overall, the secondary treatment program will have a moderate impact on the ecology of the aquatic communities of the Merrimack River Basin.

The impact of secondary treatment on the Merrimack Estuary would probably be minimal. Since the Estuary is not significantly affected ecologically by the present pollution in the Merrimack River due to the efficient flushing action, there will likely be little ecological impact on it. The organic load of the river sediment will be reduced and will lead to somewhat higher levels of benthic organisms in the Estuary.

b. Hygienic

The implementation of secondary treatment throughout the Merrimack River Basin would likely reduce the threat to human health of the Merrimack River. With secondary treatment, there is a concurrent requirement of chlorination of the discharges. This chlorination will reduce bacteria contamination within the Merrimack River. The level of chlorination normally associated with secondary treatment has been shown to eliminate most pathogens, but there is conflicting evidence on the effectiveness of chlorination in neutralizing virus contamination. The activated sludge process has been found to have varying effects on viruses. Sometimes removal is quite good, but the process in itself does not offer any dependable barrier to virus transport.

Chlorination to any degree will almost certainly reduce the health hazard from vegetables grown in the basin and which are irrigated with contaminated water from the Merrimack River.

Reduction in the bacterial contamination of the Merrimack River by secondary treatment and chlorination would probably make many areas of the main stem of the river safe for recreational activity. Other factors however must be considered before such a judgement can be made but at least the health hazard would be reduced.

c. Aesthetics

Water quality improvement in this scheme will slightly increase water clarity, color and taste. As with the other alternatives, surface material will not be significantly improved unless stringent enforcement against dumping along the riverbanks is instituted.

Potential for increased recreation and development is provided by the increased water quality. However, the potential for guiding, preserving and rehabilitating urban development is not inherent to this scheme. The extreme decentralization of sewage treatment plants reduces their scale in the landscape. Transmission lines are in turn shortened, reducing their potential for visual impact or physical access. The quality of secondary effluent is not sufficient for feasible reuse for municipal water supply or body contact recreation;

Flow augmentation is not a component of this scheme, therefore, the potential for improving the mud flats and their associated odors will be reduced.

d. Social Opportunities

Land Use

The program of universal secondary treatment would not have any major impact on land use patterns in the Merrimack River Basin. In the present urban areas, the building of secondary treatment plants is not visualized as a stimulus for the redistribution of acreage devoted to industrial, commercial, residential, or recreational uses. Generally, sewage treatment plants will be located adjacent to the water in areas devoted to industrial usages or hidden away on the edge of town.

The building of the plants will likely stimulate building activity in the areas served and extend the urban and suburban limits of the cities and towns.

Population

There is little in this system of wastewater treatment that will change the pattern of emigration established in the Massachusetts portion of the Basin. The pattern of population influx to southern New Hampshire and the recreational areas is not likely to be affected by this system.

The short-term effects of the construction phase will be felt most directly in the immediate vicinity of the several plants. A discernable influx of construction workers can be expected. However, since the size of individual treatment facilities is small, it would be unrealistic to assume that the transient worker population would increase significantly, or that employment of sufficient term to justify permanent residency would be created.

In the long-run, the existence of a cleaner river may attract families from outside the Basin, manifested first as an increase in the number of recreation visits to the lower river reaches most proximate to Boston. The steady rise in the desire of the urban dweller to experience the uncrowded calm of the outdoors may be translated into actual resettlement beyond even the present Boston suburban fringes. Should such a phenomenon take place, first immigrants are likely to be professional people who will either commute to businesses or academic institutes in a metropolitan area like Boston, Manchester, Lowell, or Portsmouth or engage in activities which can be practiced outside the urban context of labor and capital concentrations.

In the mid to upper Basin, cleaner water and associated job opportunities may entice migrants from adjacent Maine and even Canada. Since the unskilled labor supply is large and a dwindling agriculture will not be affected under the existing abatement plans, the labor supply is likely to gravitate toward the loci of building activity.

Leisure Opportunities

The level of treatment offered in the implementation program of secondary treatment will have an impact on water based recreational activity in the Merrimack River Basin. Many of the previously closed beaches could in all likelihood be reopened. Boating activity on the main stem pools will undoubtedly increase and sport fishing will increase somewhat but this will be limited by the lack of desirable species.

Municipal Services

In terms of municipal services the most immediate impact of secondary treatment will be in the form of increased water supplies for household consumption. Not only will quantity, and the possibilities for ex-urban and suburban development increase, but water quality itself will serve as an impetus for new drinking water demands. In areas which have relied on the River as a source of water supply dispite its grossly polluted state, cleaner water requiring less purification will represent a cost savings. For communities which have been forced to look to land sources both surface and ground for future supplies, the availability of river water will eliminate the need to seek out or create costly reservoir and well sites.

Costs for providing other municipal services are likely to increase significantly cleaner water or not. Certainly the addition of sewage treatment plants will increase the cost of providing sewer service to a community.

Institutional Involvement

The present system of secondary treatment offers little in terms of new institutional involvement. The system has within it the necessary federal-state-local relationships but the system does little to further local community involvement. The present plans indicate small elements of cooperation with smaller communities tying their sewer system into that of larger communities, i.e. Greater Lawrence Sanitary District composed of Lawrence, Methuen, Andover, North Andover.

Community Image

Given the fact that the communities of the Merrimack River Basin ignore the River, the indigenous population would probably react to a cleaner river in a manner of disbelief. The communities of the Basin look at secondary treatment as a burden they must bear. It does not have a bearing on the image the community puts forth, but rather a further tax burden which must be placed on the populous. Wastewater treatment plants are traditionally hidden away; there is no pride in the accomplishment of pollution control.

e. Economic

The implementation of secondary treatment in the Merrimack River Basin will have certain impacts upon the economy of the Basin. These impacts are not particularly profound and most economic projections that have been developed, as reflected in the economic baseline, have assumed this occurence.

The only major impact upon agriculture in the Merrimack Basin would be to remove the threat of the closing of the source of irrigation water (the Merrimack River) in the Manchester-Nashua, New Hampshire area. Some experts feel that the crops grown with this water already exhibit dangerous bacterial contamination. It can be assumed that moves will be taken to prohibit irrigation with Merrimack River water unless the River is cleaned up. If irrigation were prohibited, production of fruits and vegetables in this area would virtually cease. Secondary treatment should sufficiently reduce bacterial densities in the River to forestall this prohibition. Thus, secondary treatment would represent a considerable advantage to growers, an advantage which is in fact tantamount to their survival.

Secondary treatment is likely to cause little direct economic impact to manufacturing in the Basin. There might be some reduction in water treatment costs borne by the industries but this would probably be small. Indirect impacts through new industrial development may be important in this aspect, but it is unlikely that the degree of cleanup associated with secondary treatment would be enough to attract industries that require clean water.

Recreational activity on the Merrimack River is likely to increase to some degree with the advent of secondary treatment. The reduction of oxygen demanding wastes and bacterial contamination will make the river more appealing to the recreational public but the problem of possible algae growth and other lush plant growth will remain.

Taking these points into consideration it remains that the major impact of the secondary treatment program is the cost to be borne by the public in order to implement this program.

SCHEME NO. 1 -DECENTRALIZED WATER ORIENTED SYSTEM

This scheme involves development of either physical-chemical or tertiary waste treatment facilities in six areas: Franklin, Concord, Manchester, and Nashua, New Hampshire, and Fitchburg-Leominster and Lowell, Massachusetts. Renovated wastewater from the treatment facilities will be diverted to nearby lakes or streams for flow augmentation or water quality improvement, diverted to watersheds of municipal water supply, used for creating new recreational water bodies, or utilized as a source of industrial water.

The following discussion will examine this scheme as to its ecologic, aesthetic, social and economic impacts upon the Merrimack River Basin.

a. Ecologic

Terrestrial

Once each treatment system has been installed, additional land and vegetation excavational disturbances should be slight. The terrestrial impact of each treatment plant at the installation site, and its associated transmission apparatus will be significant during the construction phase. The installation of the facility would require the removal and disposal of large volumes of earth. The underground implementation of the collection facilities leading to the treatment plant will have significant terrestrial impacts in those areas where the land and existing vegetation are excavated.

The sludge, which is generated within the treatment plant and distributed on the land, should have favorable impacts if application rates do not exceed the recommended quantities of 40-50 tons per acre per year and if good management practices are used. Sludge, both liquid and dried, is a source of plant nutrients as well as a soil conditioner. The material may easily be disposed of on available lands close to the treatment plant or on nearby areas where it can be transported in large quantities - usually within a 15-mile radius. Should sludge distribution be continued on the same land area for prolonged periods of time, toxic quantities of plant nutrients (i.e. nitrogen, phosphorus, or heavy metals) may accumulate.

Digested sludge may be applied to soils on which vegetables which are eaten raw are grown, or it may be spread on hay and pasturelands if good management practices are observed.

Aquatic

The cycling of renovated wastewater in Lake Winnisquam help to alleviate its eutrophic conditions while increasing the diversity of aquatic organisms in these waters. For example, cycling renovated wastewater from the Franklin treatment plant through Lake Winnisquam could benefit the lake by alleviating the present eutrophic conditions found in the upper portions of the lake. The volume of renovated wastewater discharged into the upper lake is expected to increase the circulation in the lake. Near the outfall point the renovated wastewater could adversely affect the dissolved oxygen and the temperature in the cold water lake communities. The impact of this water on the aquatic communities in the remainder of the lake will be very slight in terms of changes in the dissolved oxygen and temperature.

A decrease in dissolved oxygen will result in stress for the more sensitive organisms leading to a decline in their abundance and a shift toward a less diverse and more simplified community. A complete absence of dissolved oxygen would result in anaerobic conditions with subsequent production of noxious gases.

It is believed that after municipal and industrial pollutants have been removed, the diversity of stream bottom species, species of fish and plant species in the River would be augmented, thus enhancing the complexity and self-regulating control of the aquatic community. The removal of municipal wastes, industrial wastes and nutrients should result in an initial decrease in the primary productivity of the River communities. Although removal of plant nutrients (nitrogen and phosphorus) from the treated waters returned to the River would alleviate the present possible eutrophic conditions, there is a strong possibility that a cumulative nutrient deficiency will result in lower productivity. Nitrogen and phosphorus are important components of cell structure and must be present in correct amounts with other nutrients to promote plant growth, i.e. primary productivity. If any nutrient essential for the plant growth is not available, then the amount of productivity occurring within the system will be curtailed.

As more stable aquatic communities develop, the annual primary productivity should increase somewhat, while the total respiration within these communities should approach unity, with the net primary production. The result will be little accumulation of organic matter in the River.

Cycling renovated wastewater through adjacent streams would produce conditions deviating from the normal stresses impinging on the aquatic communities of the stream. For example, cycling the renovated wastewater through small streams would alter the normal high and low stream flow which could change the migration and numbers of fish in the stream and alter the plant succession sequence.

Estuarine

A "clean" river entering the Estuary would cause some successional changes within it. The anadromous shad, salmon and sturgeon could be re-established with river improvement and building of fish ladders.

Pollutant reduction would increase the survival and numbers of fish and invertebrates spawning in the Estuary, which would in turn lead to an increase in the numbers of diving ducks frequenting the area. The increased survival of small invertebrates in the tidal mud flats near the River mouth would attract even greater numbers of shorebirds to the area during migration.

"Cleaning up" the Estuary could allow shellfish predators which presently are absent to become established. Such predators include the horseshoe crab, the green crab, the moon snail, the knobbed and channeled whelks, as well as various species of starfish. Whether these species will become troublesome in the absence of pollution is not presently known. It may be expected, however, that as various Estuarine organisms adjust to the reduced pollutant load, the Estuary will develop toward a relatively stable system.

b. Hygienic

Once the sewage treatment facilities in this scheme have been implemented, one may assume that the bacteria counts in the River will decrease substantially. The reduction in numbers of bacteria would greatly reduce the potential health hazards, which are now possible from recreational and agronomic use of the present River and Estuary water. Bacteria reduction in the River entering the Estuary, coupled with implementation of sewage facilities for wastes dumped into the Estuary would substantially reduce the incidence of bacteria during both high and low tide. The immediate results of this action would be the creation of an environment conducive for water recreational purposes. Later consequences would be the renewed harvesting of the shellfish beds which has been halted due to high bacteria and other pollutant contamination since 1926.

Raw sewage discharged into the River results in substantial increases of bacteria in the River segments adjacent to each major city (Figures B4 and B5).

Fortunately, the number of bacteria is reduced between the major cities through natural purification processes. However, the bacteria counts seldom if ever meet the New Hampshire water quality standards for water acceptable for bathing pruposes an MPN of 240 organisms per 100 ml.

The presence of high coliform bacteria densities indicates a potential health hazard when the water is consumed or used as irrigation water. The incidence of water associated disease fortunately is small in the Merrimack River Basin. When outbreaks occur, they are limited in extent and time, which is probably due to the lack of public use of the River for recreational purposes. Vegetables which are eaten without cooking and are presently irrigated with Merrimack River water showed a significantly greater number of fecal coliform bacteria than was found on vegetables from farms not irrigated with River water.

c. Aesthetics

As will all the advanced schemes presented, this plan will maintain the existing River width, and the existing contract of water to edge materials and slope. The plan will greatly improve water depth visibility, minimize discolorations, and reduce the visible mud flats with its associated odor, and reduce disconcerting turbidity. The reduction of nutrients will somewhat reduce bottom and surface plant growth with reduction in algal growth being the prime example. All the primary impacts of increased water quality and quantity will be introduced to the River. This plan would have the least potential for visual impact. Site disruption will be minimal with proper site design since each sewage treatment plant is small in scale in this scheme. Transmission lines are reduced in length, which in turn reduce potential impact for improving or decreasing visual and physical access to the River.

As a planning instrument, the non-regionalized water scheme has greater potential for guiding growth within a region than do the other water schemes. However, control of development among the regions is lost with the decentralization of the scheme. In addition, it must be made clear that any potential for incentive planning control can only be realized by providing a quantity of water far beyond the projected demands and being as comprehensive as possible in the wastewater treatment for all types of industrial wastes.

A third variable among the alternatives is the opportunity for altering flow characteristics by having numerous discharge points as opposed to a few discharge points along the River. In the wider portions of the River the number of discharge points for flow augmentation is not as critical as is the quality of the effluent. Thus in the northern section of the Basin where the River is narrow, the benefit from several discharge points rather than one would be advantageous.

d. Social Opportunities

Land Use

Clean water in the Merrimack River Basin will likely have an impact on land usage pattern. The property adjacent to the River itself will become more desirable for both rural and urban development as agronomic and recreational associated opportunities are realized.

Accessibility to the River's edge and recreation space within the major cities would be affected. The treatment works in this approach are to be considered community assets and designed as such, the layout of plant sites is purposely generous to open new spaces for public access. In a crowded urban environment, this means that the construction of a much-needed water renovation facility could change the character of a dilapidated waterfront neighborhood. Since much of the actual treatment machinery and tank systems can be sunk below ground level, surface space could become part of multiple-use open space. Attractively landscaped and well-maintained riverfront areas have, in the past, attracted new business and become the focal point for upturns in downtown commercial activities. Moreover, facilities may not have to be located immediately on the water's edge. Buildings housing process machinery could be used to separate existing incompatible land uses, for example, abutting residential and industrial areas. In a sparsely populated area which could accommodate such a facility, the distribution of buildings and headworks could eliminate facility clustering. Not inconceivably, new industry either requiring large quantities of clean process water or discharging large flows of pretreated effluent could locate in immediately adjacent areas to take advantage of short transmission distances. With carefully controlled planning, the open character of rural landscapes which might otherwise fall victim to suburban sprawl could be preserved.

Population

This scheme is not likely to change significantly the patterns of population movement established in the Merrimack River Basin. Over the long-term,significant population increases might be generated by the location of new industries which need clean water. In the short run, this scheme could be productive in unskilled construction jobs. If the construction activities were to be initiated simultaneously, they might well draw population from outside the Basin. It is possible that some of the workers would remain after the construction period.

With clean water, recreational opportunities are the first to materialize and with this comes seasonal population. Population mobility patterns will, over time, show a tendency to bring new residents into areas where the natural environment is most pleasant. The Estuary and the Winnipesaukee Region already demonstrate this phenomenon. Thus, by itself, the Merrimack River could become a focal point for immigration without respect to employment, though the numbers of those who could afford commuting to jobs in the Boston area, or become self-employed, are limited.

Leisure Opportunities

This system will have a great impact on water based leisure time activities. The entire length of the Merrimack River and its tributaries would become appealing for such activities. Beaches on the main stream pools would become desirable to the general public. Desirable species of sport fish would increase, thus opening many reaches of the River for high quality fishing. This impact would be limited by the accessibility of the River. Since access is quite limited at the present time, a great deal more access points would have to be created to realize this potential impact.

This scheme contains a tremendous potential for making the waste treatment facilities themselves attractive to leisure time activities. Much of the site could be devoted to parks and recreational facilities. The renovated water from the facility could be used to create new water bodies for recreational activity, especially in the lower Basin where water bodies of this type are quite limited.

Municipal Services

Since this scheme considers water treatment essentially a resource reallocation exercise rather than disposal of an undesirable product, water quality will be markedly higher than with conventional approaches. That means that the quality as well as the quantity of water available for domestic and industrial use can serve as inducements to change. Drinking water supplies can profit directly and quickly from advanced renovation techniques which make ground water recharge or even direct introduction into feeder systems possible. Considerations of water quantity are significant too because future water sources exclusive of the River are becoming scarce and costly to develop. Even if population increases are only modest, local supplies presently available will not be able to keep pace with demands. In the opinion of some experts, in fact, pollution abatement is basic to water supply requirements as imminent as 1980.

From a more practical point of view, the operational costs of providing the public and industrial users adequate water could be substantially reduced if water inputs to municipal systems were higher in quality. Corrosion and other effects harmful to pumping and transmission equipment could be virtually eliminated if uniformly high water quality could be assured. Moreover, expensive pre-conditioning such as filtration and removal of impurities would become unnecessary.

Institutional Involvement

This scheme of six regional plants achieves much in the realm of bringing about involvement between local institutions. The planning, implementation, and operation of each facility would require a high degree of cooperation between the communities involved. Through their cooperation, better qualified people could be obtained for operation and management of each regional treatment plant.

Community Image

A river is a powerful influence on a community's identity and pride. This scheme offers much in the way of improving the image of the communities along the River. As the water quality improves the River could become a community showplace of recreational activity. A clean water body readily accessible for urban recreational use is a tremendous asset to the community.

The treatment facilities with proper design would have multiple use capabilities. The outflow of renovated water can be directed into spectacular fountains and waterfalls which could be the central theme to much needed parks within the urban areas of the Merrimack River Basin.

e. Economics

Municipal Use

As the population of the River Basin increases, more and more communities will be needing new water sources. These may not be available due to their scarcity, irregular flow, and development cost. The most logical new water source is the Merrimack River which is already a source of water for Lowell and Lawrence and being considered by nine other communities.

Once the waste treatment plants in this scheme are in operation, benefits to the communities using the River for a water supply would include reduced taste and odor problems, a greater microbiological safety factor, and reduced costs of water treatment plant operation.

The availability of an ample supply of water of good quality could be a contributing factor attracting people, businesses, and industry into benefiting areas and increasing the tax base.

Industry

Improvement of the quality of the Merrimack River is likely to be of limited direct benefit to industries now found in the Basin. In general, industrial users can either use the grossly polluted water with little difficulty, or must pretreat the water. Over the long run, an abundance of clean water may induce a change in the character of industry in the Basin, attracting new enterprise dependent on it. However, the effects are difficult to assess and are not likely to be overwhelmingly important.

The net impact of pollution reduction on industry may well depend on the way such reduction is financed. If treatment operations were supported (at least in part) by effluent charges upon users of the system, some industrial concerns would be paying a high fee. Such effluent charges would distribute the costs of reducing pollution fairly among those creating it and would provide a powerful incentive to adopting more efficient production and waste-reclaimation technology.

Services and Population-Related Industries

Services, transportation, construction, finance, and the like would probably enjoy a substantial benefit during the actual construction period, reflecting a general increase in local prosperity. Such a benefit would evaporate as suddenly as it had appeared, and the termination of construction would require delicate planning to minimize locally serious (if transient) dislocations.

In the long run, pollution abatement would, by reacting beneficially on tourism, water-oriented recreation, and commercial fishing, increase the visiting and permanent population of the Basin, with corresponding stimulus to this segment of the economy.

Agriculture

Some of the present irrigation water in the Basin is obtained by taking untreated water directly from the Merrimack River. Since several experts feel that some crops already exhibit dangerous bacterial contamination, it can be assumed that unless the River is cleaned, the irrigation of these crops from the Merrimack will eventually be prohibited. Under these circumstances, agricultural production using the contaminated River water would virtually stop. While some farmers could remain in business by switching to crops that are cooked before eating, the dislocations of such change in terms of money and human capital - farmer experience and know-how - would be considerable. Eliminating the sources of bacteria and other domestic and industrial pollutants should permit irrigation using "clean" water, which would represent a considerable advantage to growers, which is tantamount to their survival. Some agricultural benefits would be derived from the nutrient content and soil conditioning capabilities of sludge disposal on the land, which is used for crop or forage production.

Fish and Wildlife

The abatement of pollution in the Merrimack would make possible the re-establishment of species of anadromous fish (alewives, blueback herring, shad, and sturgeon) that have virtually disappeared. It should not prove too difficult to re-establish shad runs once adequate fish ladders were built. Once shad runs have been developed, a valuable commercial and sport fishery would surely come into being. It may prove more difficult to reintroduce the sturgeon, however. The existence of nearby sturgeon populations in the adjacent Parker River Estuary would make natural re-introduction in the Merrimack following the clean up easier.

An ambitious fish introduction program which could bring great rewards would be the introduction of one or more species of Pacific Salmon. The most successful introductions of the Pacific Salmon to date have used either the Coho or the Pink Salmon, both of which are commercially valuable. The commercial benefit of these species would be enhanced by the fact that salmon can be harvested with little or no greater investment than that required for a lobster boat. In addition, a successful run of Coho Salmon would create an extremely valuable sport fishery throughout the Merrimack River Valley.

Indications are that fishermen in the United States spend $10.00 per fishing trip, and that their numbers will triple between 1960 and 2000. The main stem of the Merrimack River could support an additional 290,000 man-days of fishing per year.

Proper control of pollution would bring realization of the fish and wildlife potential of the streams. The entire Merrimack Basin lies within easy reach of highly-populated urban areas. By the year 2000, approximately 3,000,000 of the projected New England population of 17 million people will fish. The Merrimack River would provide many additional fishing and hunting sites for these people.

The Commonwealth of Massachusetts has estimated that the annual harvest of soft shell clans is only one-twentieth of what it could be if pollution was adequately removed from the River. The yearly commercial value of soft shell clams could be $300,000 to $1,000,000.

Visual and Cultural Environment

The effects of making the Merrimack Basin a more beautiful, more enjoyable region to visit and to live in, through alleviation of water pollution, are difficult to estimate, even qualitatively. However, it cannot be doubted that there are economic implications in aesthetic improvement, principally through enhancement of the recreational experience and tourism, attracting immigration of people and businesses, and increasing land values and related tax revenues.

Recreation and Tourism

The opportunity for boating, swimming and other water related sports would be one of the major benefits of a clean Merrimack River. The many additional visitors attracted to the region for recreational purposes would add millions of dollars to the local economy. Moreover, it is expected that the increase in local revenues from increased value of taxable property would be an important result stemming from increased recreation within the Basin.

SCHEME NO. 2 - PARTIALLY DECENTRALIZED WATER ORIENTED SYSTEM

This scheme consists of four regional advanced waste treatment facilities with associated collection equipment and treated water disposal procedures. The facilities are located at Franklin, and Manchester, New Hampshire and Fitchburg-Leominster, and Lowell, Massachusetts. Renovated wastewater from the treatment plants maybe utilized in the same manner as described in scheme #1. The facilities in this scheme will service a much larger area, and thus the quantity of renovated wastewater produced will be substantially larger. The larger concentration of renovated wastewater may make transport of this water to areas outside the Basin more feasible.

The following discussion will examine the ecologic, hygienic, aesthetic, social, and economic impacts which this scheme will have on the Merrimack River Basin.

a. <u>Ecologic</u>

<u>Terrestrial</u>

The terrestrial effects produced by this scheme will be very similar to those discussed in Scheme #1. Since two of the treatment facilities will service a larger regional area than that serviced by the comparable facilities in the previous scheme, these plants will undoubtedly require larger land areas for their implementation. Excavation of the larger land treatment sites and implementation of transmission lines will destroy the existing vegetation and greatly disturb the landscape. However, once the construction phase has been completed further disturbance of the land or vegetation should be slight.

The greater quantity of sludge generated in the larger facilities will require larger land disposal areas. The sludge-land impacts for this scheme will be the same as those stated in Scheme #1.

Aquatic

The effects of this wastewater treatment scheme on the lakes and streams in the Merrimack River Basin will be nearly the same as those noted in Scheme #1. Should renovated water be diverted to areas outside the basin the resulting changes in stream flow volume would exacerbate the problem of summer temperature stress in the River with consequent dissolved oxygen reductions.

The temperature increase will shift some aquatic species from a biologically stable situation to a very critical one and may eliminate other organisms from the lower segments of the River. A decreased oxygen content will result in stress for the more sensitive aquatic organisms. A decline in the abundance of these organisms would be a shift toward a less diverse and more simplified aquatic community. Also, the decreased river flow volume would expose larger areas of river bottom than would normally be uncovered during the warm summer and fall.

Estuarine

The effects of "clean" river entering the Estuary would result in successional changes which were discussed in Scheme #1. The diversion of 140 million gallons of water per day from the River to southeastern New Hampshire by 2020 would be a very large percentage of the River volume during times of low flow. This procedure would greatly reduce fresh water flow into the estuary, at times, which could have strong adverse effects on upstream fish populations including the young of anadromous fish.

b. Hygienic

Once the sewage treatment facilities in this scheme have been implemented, one may assume that the bacteria counts will decrease substantially. This will greatly enhance public health within the basin due to the reduced possibilities of diseases stemming from water contact recreation or vegetables irrigated with river water, as discussed in Scheme #1.

c. Aesthetics

This advanced scheme will maintain the existing contrast of water to edge materials and slope. It will improve greatly water depth visibility, eliminate water color, and visible mud flats with its associated odor and reduce disconcerting turbidity.

The increased regionalization of this scheme increases the scale of its component systems. Sewage treatment plants will have a greater impact on their individual sites, but the distribution of overall impact will be reduced. Similarily will be the increased impact of transport lines through the landscape since the lines are of greater length and require more vegetative clearing. The impact of both sewage treatment plant and transmission line will be qualified by the degree of sensitivity in design of the facility and its effect upon natural conditions.

Planning opportunities among regions is feasible with this scheme with a limited amount of flexibility within each region still possible.

Flow-augmentation outfalls are reduced in number, but their individual volumes are increased. Thus there is greater potential for impact at specific sites with this scheme than there is in the decentralized water scheme.

d. Social Opportunities

Land Use

Clean water in the Merrimack River Basin will likely have an impact on land usage pattern. The property adjacent to the River itself will become more desirable for both rural and urban development as agricultural and recreational opportunities are attained.

Accessibility to the water's edge and recreation space provided by this scheme would be similar to that discussed in Scheme #1. The number of areas which will benefit directly from the multiple use capabilities and recreation possibilities of the treatment plants sites, will be reduced. However, each available area will be somewhat larger in size.

Leisure Opportunities

This system will have an impact on water based leisure time activities similar to that of Scheme #1. Leisure activities in the lower length of the Merrimack River may be impaired should water be diverted outside the basin during periods of low river flow volume.

Municipal Services

Except for the possibility of diverting renovated wastewater to watersheds of municipal water supplies outside the basin, the impact of this scheme on municipal services will be the same as stated in Scheme #1.

Institutional Involvement

This scheme of wastewater management requires greater need and desirability for communities to work together. The scheme as proposed would have cooperation between the communities, both large and small which surround each regional treatment facility. In some instances cooperation would to extend cross county and state boundaries. The four systems seem to be of such size that good economics of scale should be realized in terms of management and quality of personnel.

Community Image

The effect of this scheme on the river as a influence for improving identity and pride is very similar to effects discussed in Scheme #1.

e. Economics

Municipal Use

Municipal use of the water supplies created or enhanced by this scheme do not differ from Scheme #1.

Agriculture

The economic agricultural impacts of this scheme are related to continued use of Merrimack River water for irrigation practices which were canvassed by Scheme #1. Economic benefits stemming from sludge disposal on agricultural land will be realized.

Industry

Improved quality of the Merrimack River is likely to have the same industrial benefits which were discussed in Scheme #1.

Services and Population-Related Industries

No additional benefits over those discussed in Scheme #1 are expected.

Recreation and Tourism

The opportunity for boating, swimming, hunting and other water and land related sports will be major benefits of a clean Merrimack River. Other benefits have been discussed in Scheme #1.

Fish and Wildlife

Fish and wildlfe's impacts and benefits created by this scheme are similar to those discussed in Scheme #1.

Visual and Cultural Environment

The effects of making the Merrimack Basin a more beautiful, more enjoyable region to visit and to live in, through alleviation of water pollution, are difficult to estimate, even qualitatively. However, it cannot be doubted that there are economic implications in aesthetic improvement, principally through enhancement of the recreational experience and tourism, attracting immigration of people and businesses, and increasing land values and related tax revenues.

SCHEME NO. 3 - CENTRALIZED WATER ORIENTED SYSTEM

Sewage from local communities would be transported to one of the two regional plants for treatment prior to reuse or placement into the River. Possibilities for reuse of the renovated water will be the same as those discussed in Water Oriented Scheme #1 and #2. The following discussion will deal with the ecologic, hygenic, aesthetic, social and economic impacts of this scheme.

The two regional tertiary treatment facilities will be located south of Concord, New Hampshire and in the area of Lowell, Massachusetts. The placement of the second facility would be dependent upon whether the renovated wastewater is diverted from the Basin near Lowell to the Boston area or is placed back into the River south of Nashua.

a. Ecologic

Terrestrial

Once each treatment system had been installed, additional land and vegetation excavational disturbances should be slight. Sludge generated by the two regional treatment plants will be substantial, making total sludge disposal on land impractical. Therefore, sludge disposal will be accomplished using incineration plants, which will be a component of each treatment facility.

Incinerator design theoretically will eliminate any harmful or noxious gases. However, sludge combustion may cause sulphur, nitrogen or heavy metal oxides, in addition some particulate matter to be emitted into the air. The terrestrial effects of these gases and materials may be initially slight; the offensive odors and the heavy metals which may be produced, would create an air pollution condition in the areas adjacent to the treatment plants.

The residues from sludge incineration will consist essentially of inorganic salts which may be put in a landfill. Some of the soluable ions in the residue will be absorbed by the soil ion exchange complex, while others may find their way into the water table or nearby surface water. Because the size of these treatment plants will be larger than those in the previous scheme, the terrestrial impact of each treatment plant at the installation site and where transmission lines must be constructed will be very significant during the construction phase. The installation of the facility and the associated apparatus will require the removal and disposal of large volumes of substrate.

Aquatic

This scheme will have favorable impacts on the central River region, since the treated water from the regional Concord plant will be returned to the River at Concord. Removal of the pollutants will reduce the environmental stresses imposed by the present nitrogen and phosphorus levels, turbidity, and dissolved oxygen. This should increase the numbers of species of stream bottom organisms, fish and plants.

In those segments of the Merrimack and Nashua Rivers where wastewater is not returned to the River but is diverted to the regional treatment facilities, or diverted outside the Basin, the decreased river flow volume may expose areas of stream bottom which are normally covered.

Restoration of certain anadramous fish species which rely on high volumes of seasonally available water prior to spawning runs will be adversely affected by the loss of attractant waters. The flow reduction in River segments downstream from Lawrence will also decrease the available fresh water habitats due to salt water intrusion up the river.

While the loss of flow is important to all aquatic communities in the River Basin, the reduced stream flow will be most significant during critical periods of low summer flow in the lower portions of the River. Water temperature increases could alter the distribution of plant and animal species within the water communities by shifting a species from a biologically stable situation to an unstable one, and possible eliminate the species from the community. An associated decrease in dissolved oxygen may accentuate stresses for the more sensitive organisms, leading to a decline in their abundance and utlimately a shift toward a less diverse and more simplified community. A complete absence of dissolved oxygen would result in anaerobic conditions with subsequent production of noxious gases.

Removal of plant nutrients (nitrogen and phosphorus) from the treated waters returned to the River would alleviate the present possible eutrophic conditions. However, there is a strong possibility that a cumulative nutrient deficiency will result in lowering productivity below normally expected levels.

As the treatment facilities are implemented the initial effects will be a fluctuation in yearly aquatic productivity. As municipal and industrial waste nutrients in the River are "flushed-out", the primary productivity of the aquatic communities will decrease somewhat, but ultimately the amplitude of yearly productivity fluctuations will decrease, as "favorable" aquatic communities develop in the new River environment.

Estuarine

The effects of this scheme on the Merrimack Estuary are similar to those noted in Scheme #2. It may be expected, however, that as the Estuary organisms adjust to the reduced pollutant load, and as new organisms come to inhabit the Estuary, it will develop into a relatively stable system.

b. Hygiene

Implementing this scheme should greatly reduce the number of pathogens in the River, thus reducing the potential health hazards, stemming from recreational and agronomic use of the present River and Estuary water. Other hygenic impacts caused by this scheme will be the same as those discussed in Scheme #1.

c. Aesthetics

As with all schemes this advanced scheme will maintain the existing river width and the existing contrast of water to edge materials and slope. It will improve greatly water depth visibility, eliminate water color, and visible mud flats with its associated odor and reduce disconcerting turbidity.

The high degree of regionalization in this scheme increases the scale and impact of the two sewage treatment plants. In this solution, the site specific impact is the greatest while the distribution of impact is minimum.

Transmission lines are of greater distances and traverse more rugged topography than in Schemes #1 and #2. This would increase access to the river, yet it would be more difficult to design the facilities so as to produce a positive visual impact.

Planning and development control among regions is greatest in this scheme while flexibility within the regions is reduced.

Opportunities for altering flow characteristics at numerous points along the River are reduced through regionalization. However, the increased volume of water available from the two regional physical-chemical plants provides a greater potential for visual impact to a specific site. The effect of impacts resulting from numerous non-regionalized plants compared to the effect of impacts from two regionalized plants needs further investigation before evaluation.

d. Social Opportunities

Land Use

The impacts related to urban and rural land use patterns stemming from clean water in the Merrimack River Basin will not be unlike those discussed in Scheme #1.

Population

This scheme is not likely to significantly change the population patterns which were discussed in Scheme #1. The two regional plants should be of such size that a full time permanent professional and skilled staff will be required for plant operation and maintenance.

Leisure Opportunities

Impacts affecting leisure activities should be the same as those indicated in Scheme #1.

Municipal Services

Same as discussed in Scheme #1.

Institutional Involvement

In this scheme of wastewater management, the Winnipesaukee, Concord and Manchester subregions are tied together, as are the Fitchburg-Leominster, Nashua, and Lowell-Lawrence-Haverhill subregions. This in itself necessitates a high degree of intergovernmental cooperation to implement this scheme. Because of the large area serviced by each plant it is believed that economies of scale in management and operation, better management, and less total cost will be achieved in treatment facilities of this physical size.

Community Image

Same as discussed in Scheme #1.

e. Economics

Municipal Use

Similar to those impacts discussed in Scheme #1.

Agriculture

Eliminating the sources of bacteria and other domestic and industrial pollutants should permit irrigation using "clean" water, which would represent a considerable advantage to growers, an advantage tantamount to their survival, as was discussed in Scheme #1. Benefits stemming from land disposal of sludge would not be realized since sludge disposal will be accomplished by incineration.

Industry

Industrial benefits will be similar to those discussed in Scheme #1.

Services and Population-Related Industries

The impacts of this scheme on services, transportation, construction, finance, and the like would not differ substantially from those previously discussed in Scheme #1.

In the long run, pollution abatement would beneficially affect tourism, water-oriented recreation, and commercial fishing and increase the visiting and permanent population of the Basin which would act as a stimulus to this segment of the economy.

Recreation and Tourism

Economic benefits of this scheme will be similar to those mentioned in Scheme #1.

Fish and Wildlife

Economic impacts of this scheme on the fish and wildlife will be similar to those discussed in Scheme #1. Wildlife may benefit most due to increased habitats along the transmission lines. The larger variety of terrestrial habitats may result in an increase of certain species of land animals, i.e. deer and grouse.

Visual and Cultural Environment

The effects of making the Merrimack Basin a more beautiful, more enjoyable region to visit and to live in, through alleviation of water pollution, have been previously discussed in Scheme #1.

In the long run, pollution abatement would beneficially affect tourism, water-oriented recreation, and commercial fishing and increase the visiting and permanent population of the basin which would act as a stimulus to this segment of the economy.

SCHEME NO. 4 - DECENTRALIZED, LAND ORIENTED SYSTEM

This wastewater treatment scheme will implement a land disposal method of a) spray irrigation for crop use and infiltration or b) spray irrigation for overland flow for all municipal, industrial, and storm flows generated within the Basin. Its major significance is a diversion to southern Maine of effluent generated from the Lowell, Lawrence, Haverhill area. The following discussions will delineate the ecologic, hygienic, aesthetic, social and economic impacts inherent with this particular wastewater treatment scheme.

a. Ecologic

Terrestrial.

The major impact presented in this scheme is the utilization of large areas of land. If these areas are effectively managed under a multiple use concept, the benefits accruing will be great. Proper management and planning, therefore, are a crucial issue in the implementation of this scheme.

The terrestrial disruption at any given treatment site will, of course, be significant but the overall impact within the Basin will be minimal. The collection and distribution facilities tied in with such treatment sites would presumably be underground, and through proper engineering and planning, minimal adverse impact could be assured.

The major impacts then, be they adverse or favorable, will be dependent upon the acreage needed for each disposal method and the rates of application of the secondary effluent.

Excessive applications of wastewater on soils found in the northern part of the Basin - generally acid, never base saturated, and often developed on top of clays - could aggravate existing drainage conditions.

Given application rates of 1" per week, depressions that hold pockets of perched water would stay wet during periods of the year when they are usually dry. These conditions could alter plant species composition of such sites, largely favoring red maple reproduction. The total area involved is, however, relatively small and the possible species change would not be termed a serious ecological impact.

It is possible that the breeding areas of some insects, i.e. mosquitoes, could be enhanced within the irrigation areas and variations in insect diurnal movement patterns could result. The impact again would probably be a minor one.

The addition of nitrogen and moisture by means of spray irrigation could result in the acceleration of bacterial action and subsequent increased reduction of forest duff (surface organic matter). The possibility that soil micro-organism processes would be negated by excessive chlorine concentrations in the applied wastewater would have serious impacts within the disposal areas. Possible adverse seed germination responses and plant stresses induced by changes in the soil water regime could also be significant in the disposal areas.

For example, wastewaters, if applied in large quantities, may adversely affect the pitch pine and red pine stands found in the central portion of the Basin. Excessive wastewater could cause spurts in vegetative growth in these species with concomitant low root growth, which would result in reduced support. These shallow rooted trees would subsequently suffer high rates of windthrow.

In terms of an overall impact on macrofauna, wastewater discharges could be extremely beneficial if managed properly. This observation is equally valid in terms of the agronomic and forest resources of the region if appropriate management practices were adopted.

With the decline of land areas in pastures and fields, the deer, hare, rabbit, grouse and woodcock populations have been diminishing. This is also true of a wide variety of other small animals and song birds associated with such habitats. The potential to strengthen this valuable natural resource through an integrated wastewater disposal, forestry, wildlife management system is very great.

The future of forestry in New Hampshire lies with fast growing species on accessible fertile soils. Wastewater would be a positive factor in terms of both quantity and quality of wood products and their subordinate benefits.

For example, if aspen forests were planted, several possibilities arise:

1. Aspen is an excellent species for wildlife production and relatively easily managed. Aspen is the key to the sustenance of ruffled grouse populations. Other species such as woodcock, deer, and cottontail rabbits are also exceedingly favored by aspen forests.

2. Aspens provide fast fiber production for pulp purposes. Maximum tree growth is attained in 40 years; 40-year rotations (i.e., clearcut portions every 10 years) will yield a six percent return on an investment.

3. If wastewater irrigation were initiated on aspen stands, application could probably begin quite early in the spring and continue late into the fall, since the green inner bark of aspen photosynthesizes successfully before the trees leaf out and after the leaves drop. Further reinforcement stems from the fact that aspens will grow well on very wet soils. Other trees that are highly water-tolerant include willows, cottonwoods, and maples.

4. The whitetail deer is probably the most important big game species in New Hampshire. Deer are not affected generally by the level of management undertaken; the primary controlling factor in deer population levels at the present time is the amount of hunting pressure exerted. In those areas sustaining deer, a square mile supports approximately six deer. Since deer browse primarily around the edge of forest areas, increased productivity in forests due to spray irrigation of wastewater might induce deer to browse in the forests. More significantly, if portions of forested land were cut back to accommodate the installation of irrigation pipes and relay pumps, the habitat potential would be improved (not only for deer but all wildlife as well), because of greater fertility and growth. One square mile could sustain around 15 head of deer; that is, more than twice the current rate. If, in addition, a vigorous forest management program were initiated, the potential faunal production is very great.

Regardless of the method used, either spray irrigation for crop use and infiltration or spray irrigation for overland flow, and if the rate of application and infiltration in any given instance were to exceed the percolation rate of water away from the root zone of the forest or vegetative cover, a build-up of a water saturation zone is possible. Such a build-up would eventually encompass the plant roots. A long term exclusion of the aeration processes would result in the eventual death of the plants. Thus wastewater applications will have to be judiciously applied and strictly regulated at all times to prevent such a situation. Renovation of the effluent wastewater would be sufficient and percolation will not be too rapid as to cause contamination of the groundwater.

Incorporated into the irrigation and overland flow systems are a series of lagoons which have their own ecological ramifications. Large lagoon installations for land disposal systems in the Basin will create major terrestrial impacts, the most significant of which is the amount of acreage that would be taken out of production. Generally, open fields are the areas chosen for such lagoons because of their accessibility and the minimal cost required to develop such areas.

The possibility exists for using natural bogs, swamps, swails etc. as components of the land wastewater disposal scheme. Bogs could be natural lagoons if managed properly. Bogs typically support some 30 to 40 floral species (plants and trees). A much more diverse and productive bog environment is possible through wastewater enrichment, combined with "natural" lagooning.

The issue of sludge disposal raises some salient points that can most appropriately be related with the various terrestrial impacts previously presented. When properly treated, sludge can be used on land in urban areas - golf courses, lawns, etc., as well as rural farm areas to improve the soil and add plant nutrients.

In many areas of southern New Hampshire, unsightly and unproductive areas exist because of sand and gravel removal. The possibility of rejuvenating these "scars" through proper application of digested sludge and selected plant species planting is both promising and intriguing.

In summary, the benefits to wildlife or forestry should be quite great through proper wastewater applications, good successional patterns, open areas, fertilization, water availability (with more permanent stream flows and more valuable tree species).

Aquatic

As noted previously the Basin was classified into cold, intermediate, and warm water communities for purposes of delineating the various riverine impacts presented by each scheme (Plate 2).

In general, this scheme appears to have a beneficial effect only in the intermediate community. The water diversions to the irrigation areas will likely perturb the warm water community in the main stem of the River. The decrease in the flow of the main stem of the River will expose large areas of stream bottom normally covered and can cause a marked increase in temperature and a concurrent decrease in dissolved oxygen. Intensifying the temperature and nutrient deficiency stresses results in a lowered productivity in the warm water zone. Certain species of anadromous fish rely on high volumes of seasonally available water and loss of attractant water will adversely affect their restoration.

The decrease in dissolved oxygen will result in stress for the sensitive organisms leading to a decline in their abundance and thus a shift toward a less diverse and more simplified community. The increase in temperature will also produce a similar situation in that the organisms present will move rapidly from a biologically suitable condition to that of a stress situation.

The stretch of River from Lowell-Lawrence-Haverhill to the River mouth will receive a significant unfavorable impact. The water diversions from this area to southern Maine will cause a decrease in available freshwater habitat due to saltwater intrusion up the River. Changes presented due to decrease in water volume should be evaluated with the consideration of negating the possibility of restoring the spawning runs of anadromous fish.

In terms of ecological stability the cold water communities will not be appreciably affected while the warm water communities will be adversely affected. Overall the removal of pollutants in the entire Basin will favorably affect species diversity with an associated favorable effect on ecosystem stability.

Estuarine

Since it is impossible to divorce the River itself from the Estuary, effects produced by this Basin-wide management scheme will have an associated effect on the Estuary.

Since there is no evidence that the plant population of the Estuary is adversely affected by the pollution of the River, plants living in the Estuary very probably benefit from the presence of nutrients brought into the Estuary by the River. In fact, the productivity of the Estuary could be reduced upon removal of the incoming nutrient supply. This is unlikely, however, for the Estuary is believed to derive most of its nutrients from the extensive surrounding salt marshes. The question needs to be developed further since the plants are important to estuarine fauna in that they provide a source of food and a means of shelter for the young of many species of fish.

In relation to water fowl a reduction in the amount of pollution in the River will increase the survival of fish and invertebrates spawning there and will likely lead to an increase in the numbers of diving ducks frequenting the area. Increased survival of small invertebrates in the mud of the tidal flats near the River mouth will attract even greater numbers of shorebirds to the area during migration. The general effect of reducing pollution in the Merrimack River will be beneficial to the water bird populations of the area.

One possible major harmful result of cleaning up the Estuary is that shellfish predators which presently are absent might be able to invade the Estuary in the absence of pollutants. Such predators include the horseshoe crab, the green crab, the moon snail, the knobbed and channeled whelks, as well as various species of starfish. At present not enough is known about the reactions of these species to the pollutants found in the Merrimack Estuary to predict whether they will become troublesome in the absence of pollution.

b. Hygienic

Since the overall situation with respect to bacteria and viruses within the Basin can best be described as a potential health hazard, this wastewater treatment scheme will reduce this potential for incidence of water associated disease. The problems associated with the biological pathogens in the water are of major significance in this scheme since the treatment generally afforded water in the control of enteric bacterial infection is at times not sufficient for the control of viruses.

It appears that the current health hazard inherent by ingesting River water will be eliminated with the removal of enteric pathogens. Spray irrigation of crops, especially those eaten raw can be implemented without the threat of possible bacteria contamination. Also, the shellfish beds in the Estuary can be re-opened to harvesting upon removal of the present bacterial contamination.

In the overland flow system, a number of steps may reduce the viral content of the sewage. These include aging, adsorption onto clay particles, environmental insults, and others.

In the spray irrigation and infiltration scheme the steps in viral elimination are aging and sand filtration. Neither of these steps can be relied upon for effective viral elimination. The sandy soil may contain certain types of clay having variable efficienty in viral adsorption. In total, the overall system does not present a very strong barrier for virus.

The system of storage lagoons implicit with this scheme presents a distinct possibility of spreading disease organisms. Various waterfowl species, such as black ducks, flock to lagoon areas to feed. High rates of enteritis contamination were observed in several specimens that were subjected to laboratory analysis. The possibility of spreading disease organisms through the migratory activities of waterfowl should be evaluated through further research.

Removal of the various toxicants and the heavy metals by this scheme and their resultant impacts within the River system and various food chains needs to be further evaluated.

c. Aesthetic

The improvement of water quality and its attendant aesthetic impacts as identified in the water schemes will be the same for this land scheme. Its main influence, unlike the water schemes, will be upon the land; planning for land use and visual impact of system components, i.e. (lagoons, transmission facilities, and irrigation lands).

Opportunities for preserving open space, creating new open areas and guiding development are manifested in this scheme. In the Hudson, Salem, Nashua area of New Hampshire, proposed spray irrigation on existing agricultural lands and some advantageous clearing of new lands would not only preserve present land use but also provide much needed relief from monotony and a new impetus to some agriculture. Open land is needed in the Manchester area and if properly designed, transmission lines and irrigation areas would not only provide the open land, but would guide development as well.

The lagoons will be the most difficult part of the land scheme to visually integrate into any landscape. Even though water bodies are a visual advantage in most Merrimack landscapes, this type of wastewater water body is not necessarily an advantage because certain undesirable odors and side effects are possible. In the northern Basin - Northfield, Suncook and Concord - lagoon sites will require extensive land manipulation and disruption of the natural conditions. The major issue in the

Hudson, Salem, Nashua region is the highland location of large lagoons in a settled and developed rural town landscape. The lagoons proposed on Fort Devens will require clearing of land of which the remaining wooded context would be a desirable visual contrast. The limited access to the lagoon site may be desirable.

Unless clearing were necessary for site preparation, the effects of irrigation will be variable by the season and day. The flat lands in Fort Devens are advantageous for irrigation and some additional clearing of forested land is desirable. Proposed spray irrigation in the Hudson, Salem, Nashua area is effectively clustered for local visual variation.

Overland flow sites would not visually disturb the landscape. On overland flow sites in the Northfield-Suncook area clearing of open land in wooded landscapes should be considered both for visual interest and possibly to speed evaporation. Both overland flow and spray irrigation in the Concord area would be visually advantageous.

The pump house sites are all generally in a good location. The land is open in parts and wooded in others, topography not too steep, and a variety of viewing positions and distances are possible. The visual success or failure of each plant will be site specific depending on the relation of the mass, form, height, material and siting of the plant to major landforms and its ability to blend with the existing industrial development.

Transmission in the land scheme far exceeds the length of transmission associated with Scheme No. 3 and would suffer the same constraints.

The visual disruption through the more rugged terrain of the northern Basin would be extremely difficult to avoid. The consequences of long distance transport would be manifest in the transmission to Maine. In the Concord area the transport distance would be reasonably short but over rugged terrain. If handled properly, this could open up dramatic views and vistas provided that there was minimal geometric scarring of the landscape.

The altering of flow characteristics to stabilize river flow will be regionally pervasive through net surface recharge from spray irrigation and overland flow sites.

d. Social Opportunities

Land Use

Clean water in the Merrimack River Basin will likely have an impact on land usage pattern. The property adjacent to the River itself will become more desirable in both the rural and urban environment. Instead of people and communities turning their backs on the River, they will turn and face the River.

This system is likely to exert the most powerful effect on the future of land use development. First, in the Basin, a total of 60,000 acres is required. Though composed of fragmented plots varying in size from 10 to 1000 acres, that total represents a substantial portion of the green land, forest and farm, near to urbanized areas. If the lagoon system, settling ponds, and ancillary works were carefully laid out and first consideration were given to the concept of multi-purpose design, these acres would not necessarily be withdrawn from the supply of land accessible to the public or private industry.

On the contrary, the scheme would function simultaneously to preserve the natural character of the land and integrate compatible land uses. For example, a nuclear-fueled generating facility might well utilize a water body created for treatment purposes to solve its thermal discharge problems, and at the same time provide space for recreational activities consistent with any seasonal irrigation operation. In the case of nuclear power plants, particularly, the isolation advantages of low-density areas are obvious. Quite apart from its primary water renovation function, the land oriented scheme could stimulate regional economic planning in the Merrimack Basin.

Land uses completely ignored by conventional techniques become possible with land disposal. The irrigation of cultivated farmland can produce an upturn in a declining sector of the economy. If farming in the Basin continues to decline, it is likely that the land will fall idle and the people will migrate to urban areas to find industrial work. To the extent that irrigation techniques can reverse this trend, the indirect benefits of maintaining the land and curtailing further urban congestion would be considerable. This is not to say that the dollar productivity of agriculture would make it self-sustaining. In fact, there are sound reasons why farming as we know it has no place in modern New England. However, other factors like opportunities for those who wish to remain on the land or even return to it are powerful arguments for shoring up a beneficial, if not lucrative, economic activity.

For land areas presently in forest - and much of that acreage is part of existing farms - irrigation presents the opportunity for forest management activities. The national supply, and certainly the New England supply, of first growth timber is rapidly dwindling. Increasingly, lumber operators are hard-pressed to find straight stem trees which yield large quantities of defect-free board. The wood industries, in fact, are coming to rely more and more on composition board and other products produced from shredded common-grade trees as their first-line market offerings. However, there appears to be good reason for supposing that a market demand for solid wood of high quality will continue to exist; the public has not appeared ready to accept composition materials for items such as furniture, for example. Postulating that the call for high quality timber will prompt loggers to seek out new stands and pay premium prices, it makes sense to consider the possibilities of creating new supplies. In-forest disposal of treated effluent provides such an opportunity.

Not only the facilities themselves, but the collection lines they service must be considered. It is not unreasonable to assume that wherever sewage lines go, housing development will follow. Well planned, this consequence may not be undesirable. However, the prospect of proliferation of residential development in presently undeveloped areas is likely to meet opposition from local communities anxious to preserve the character of their towns. In sum, the land disposal alternative is a broad blade which cuts two ways: without strong, comprehensive controls on land use, it could destroy the landscape it seeks to serve.

Population

This scheme is not likely to change significantly the patterns of population movement established in the Merrimack River Basin. Over a long-term, the population increase generated by the location of new industries needing clean water could be quite significant. In the short run, this scheme could produce a number of unskilled construction jobs. If the construction activities were to be initiated simultaneously, they might well draw population from outside the Basin. It is possible that some of the workers would remain after the construction period.

With clean water, recreational opportunities are the first to materialize and with them come seasonal population. Population mobility patterns will, over time, show a tendency to bring new residents into areas where the natural environment is most pleasant. The Estuary and the Winnipesaukee Region already demonstrate this phenomenon. Thus, the Merrimack could become a focal point for immigration without respect to employment, though the numbers of those who could afford commuting to jobs in the Boston area or become self-employed are limited.

This scheme has some interesting impacts on rural population because it focuses intensive activity in the countryside. The land disposal technology and its concomitant agricultural and forestry potentials might hold the line on population decrease in rural areas and relieve present residents adequately. In this sense, this wastewater management scheme could - even in the long term - hold population density in Basin cities at desirable levels, counter the steady pattern of depopulation in rural areas, and allow more time for more uniform decision-making on the directions of future growth.

With the land disposal scheme there is a potential displacement of rural populace in the areas finally selected for the implementation of the scheme. This would not probably be a significant number of families in terms of the Basin, but certainly is a significant fact to those displaced.

Leisure Opportunities

This scheme appears to have a great impact on water related leisure time activities. The entire length of the Merrimack River and its tributaries would be appealing for such activities. Beaches on the main stem pools would become desirable to the general public. Desirable species of sport fish would increase and open up many reaches of the River for high quality fishing. This impact would be limited only by the availability of access to the River. Since access is quite limited at the present time, a great many access points would have to be created to fully realize this potential impact.

In the land disposal areas, certain types of recreational activity would certainly be compatible. This land would, in large part, be available for wintertime activities. In the summer certain transient activities such as riding and hiking are compatible. Hunting on these areas is quite compatible and should be good in terms of success if the increases in wildlife seen in the ecological impacts section manifest themselves.

Municipal Services

Because this scheme considers wastewater treatment essentially a resource reallocation exercise rather than disposal of an undesirable product, water quality will be markedly higher than with conventional approaches. That means that the quality, as well as the quantity, of water available for domestic use, can serve as inducements to change. Drinking water supplies can profit directly and quickly from advanced renovation techniques which make ground water recharge or even direct introduction into feeder systems possible. Considerations of quantity are significant because future sources exclusive of the River are scarce and costly to develop. Even if population increases are only modest, local supplies presently available will not be able to keep pace with demands. In the opinion of some experts pollution abatement is basic to water supply requirements as imminent as 1980.

From a more practical point of view, the operational costs of providing the public users adequate water could be substantially reduced if water inputs to municipal systems were higher in quality. Corrosion and other effects harmful to pumping and transmission equipment could be virtually eliminated if uniformly high water quality could be assured.

Institutional Involvement

This wastewater management scheme poses some interesting questions in the realm of institutional involvement. The individual subsystems are not large in terms of the units of government they entail but by the nature of the scheme, the land areas of many other jurisdictions become involved. For example, the wastewater from Manchester is irrigated in towns as far away as Henniker and Salem, New Hampshire. Also this scheme crosses State boundaries in that the wastewater from Fitchburg-Leominster, Massachusetts is used as an irrigant in New Hampshire. The transport of the wastewater from Lowell-Lawrence-Haverhill to the Maine Plain is of particular interest in that Maine's wastewater problems are not solved in this scheme, but rather she becomes the solution for some other area. If the degree of cooperation necessary to achieve this system can be brought about, it will be a tremendous showpiece as to what can be done.

Community Image

A river can be a powerful influence on a community. Since the communities of the Merrimack River Basin do not now look at the rivers, a clean river can add to the dimensions of a community: identity, pride and a multitude of functional uses. The rivers will be looked at, sought after and associated with. They will become part of the communities rather than things that are just there. People will work to tear down the walls that hide the rivers and thereby make the rivers part of them again. Rather than the waterfront being the industrial district, people will want to live and recreate in this area.

This scheme also offers much in the way of improving the image of communities along the River. With clean water the River can become a showplace of the community. A clean water body of ready access to the urban city is a real plus to that city. People will want to live in a community like this.

The land disposal site can be a source of pride to the community or a thing to hide depending on how it is handled. If carried out as concieved as a multiple use project, the site can be beneficial and an improvement to the community image. People will be proud to have it, show it off to their visitors and include it in their daily lives.

e. Economics

Municipal Use

As the population of the River Basin increases, more and more communities will be needing a water supply of sufficient volume. Such sources will not be available at remote locations due to their scarcity, irregular flow, and development cost. The most logical source is the Merrimack River, which is already used as a water supply by Lowell and Lawrence, and under consideration by nine other communities.

After waste treatment plants are in operation, benefits to the communities using the River for a water supply would include reduced taste and odor problems, a water that has a greater biological safety factor and reduced costs of water plant operation.

The availability of an ample supply of water of good quality could, in addition, be a contributing factor attracting people, businesses, and industry into benefiting areas, increasing the tax base. In some cases, the output of the advanced waste treatment plants would itself be available for use as a community water supply input with comparable savings.

Agriculture

Much of the area deemed suitable for land disposal is located along the Concord-Nashua stretch of the Merrimack River. This area is in fact one of the more agricultural portions of the State, and thus provides some opportunity for productive use of the land irrigation scheme.

Land disposal of wastewater is considered to be infeasible for fruits and vegetables eaten raw since effluent bacterial levels are likely to be above health standards. Consequently in order to be used as land water disposal sites, land presently used for certain fruits and vegetables would have to be converted to crops that are cooked before human consumption. Much of the Concord-Nashua stretch does in fact specialize in products eaten raw, though the farms used for these purposes are usually too small to make irrigation of wastewater profitable. Thus, not only conversion to a different crop, but also cooperative irrigation agreements would be needed to make use of this land for wastewater irrigation purposes.

A good deal of the present irrigation is practiced by taking untreated water from the Merrimack River. Since some experts feel that the crops already exhibit dangerous bacterial contamination, it can be assumed that eventually, unless the River is cleaned, the irrigation of these crops from the Merrimack River will be prohibited. Under these circumstances, production would virtually stop. Thus, the clean River would represent a considerable advantage to growers, an advantage which is in fact tantamount to survival. Needless to say, the losses sustained by a halt in production would not amount to the entire value of the production since it is likely that farmers who intend to stay in the business would change crops. But in any case, the burden of switching might be severe enough (not only from a financial viewpoint, but also from the viewpoint of human capital: farmer knowhow, experience with growing and distribution, etc.) to cause significant frictional losses as a net result.

Other vegetables like squash growing in the area could potentially benefit from the use of wastewater as an irrigant as well as a fertilizer. However, an important question arises as to the practicability of using wastewater as an irrigant if the River is in fact clean, and could be used directly. For the most part, irrigation areas would have to be located near the River anyway in order to take advantage of the sandy soils surrounding the riverbed.

Since the majority of wastewater disposal areas are located near the River, it is likely that farmers would prefer the control and familiarity of conventional irrigation and fertilizer techniques unless the alternative of wastewater land disposal were made highly attractive by financial incentives. The nature of these incentives amounts to subsidies by urban areas to farmers permitting disposal. Otherwise the value of the wastewater as fertilizer would alone have to make its use and the accompanying inconvenience worthwhile.

Some physical problems exist in using wastewater as an irrigant for fields used often as pasture. Only partial use of the fields would be possible in that the animals could not be permitted onto irrigated acreage until at least one day after irrigation, since they may produce depressions in the pasture which could act as collectors of wastewater. If three days of irrigation are applied, the land would be useful for three-sevenths of the time. However, additional hay production (possibly as much as 100%) could justify some system of land rotation for pasture use.

There seem to be no outstanding problems in using wastewater as an irrigant for forest land. With careful management alone, good profits could be achieved in the New England forestry industry. From evidence collected by Pennsylvania State University in the course of forest wastewater irrigation experiments, significant improvements can be obtained from well managed forest irrigation.

Management is of primary concern, and changes in land values may not allow forest production in the selected areas. However, if some sort of green belt scheme is guaranteed by the local governments for quite different considerations (air quality, natural beauty, etc.), well-run selective cutting operations could achieve economic significance in the area. One problem which should be studied in greater detail is the type of forest production generated by such programs. Some experts feel that foliage growth may overshadow trunk growth under heavy irrigation-fertilization schemes and the net effect would not be advantageous from the viewpoint of commercial lumber production.

Hay and similar crops are known to respond well to wastewater applications. Production might increase 50-100%. The primary difficulty in the New Hampshire area is not so much the productivity of the land but rather management problems that are attributable to small-scale farming operations in the area.

The Pennsylvania State Study estimates that year-round application of effluent is equivalent to 1,500 lbs. of commercial 12-9-10 fertilizer. Since the price of the closest commercially-available fertilizer in the area (10-10-10) is a one inch application for the summer months only, it would have a value of approximately $25 per acre. A Louisiana Polytech study estimates considerably lower fertilizer benefits per acre of $14.50, but does not give any estimate of the rates of application used. In light of the conflicting information, estimates of fertilizer content were revised downwards to $40 per acre for three-inch irrigation for about twenty-six weeks per year.

Effluent irrigation costs (excluding pumping to the property) are about the same as irrigation costs from nearby water sources, about $50 per acre. The Louisiana study researchers found no major problems in using conventional equipment for irrigation with sewage effluent provided proper size sprinkler nozzles are selected.

The extreme case here is the situation where we value the benefits resulting from land disposal at the cost it would take to provide equivalent fertilizer and irrigation. This assumption of course is quite unrealistic, and might at best be used as a guide in areas where all of the irrigated land area is used in commercial farming, and where irrigation must necessarily be practiced as a result of land and climate conditions. This is clearly not the case in the Merrimack Basin.

The maximum benefit is the amount of land to be irrigated times the value of irrigation as estimated by the cost of irrigation from an easily accessible alternative water source. In the Merrimack Basin some 80,000 acres are scheduled for land disposal. Multiplying by $50 per acre, the annual value of the land disposal scheme as an irrigation method under the maximum benefit assumption is about $4 million.

The value of the fertilizer at $40 per acre at three inch application times 60,000 acres scheduled at this rate of application, plus $15 per acre at one inch application (overland flow) times 20,000 acres scheduled at this rate would equal about $2.7 million.

Irrigation possibilities in southern Maine would add an additional $1.8 million. Total maximum annual benefits for the land disposal scheme would amount to approximately $8.5 million.

In the two most heavily irrigated counties in New Hampshire, only about 1855 acres are presently irrigated, as opposed to the projected 80,000 acres. Consequently, the use value of the land disposal alternative must be revised downward in face of the available evidence.

The effect of irrigation on woodland is estimated here not by the fertilizer value of the effluent, but rather by some rough estimates of production increments likely to be brought about by forest irrigation. It is optimistically assured that 50% productivity increases can be expected from effluent use. Farm and forest products amounted to about $750,000 for about 115,000 acres of farmland in forests. The additional forest product due to land disposal, given a 50% increase in productivity, would amount to about $200,000 annually.

Annual benefits of about $500,000-1,000,000 may be expected to result from the land disposal scheme from the viewpoint of the agricultural industry. These benefits assume that the farmer spends no labor or maintenance work in connection with the land disposal system, that is, the water management authorities take full responsibility for operation and costs. While these benefits are sizeable from the standpoint of the industry (amount to about 5% of agricultural sales), they are probably dwarfed by the cost of installation of distribution and irrigation systems. And most importantly these computations are based on the critical assumptions that the fertilizer and irrigation effects of the wastewater system fit ideally the growing requirements of the crops and forests sprayed. A good deal of research must be done before we can be assured of even the approximate validity of this assumption. If it is not valid, the system could generate additional costs instead of savings.

A comparison of the maximum possible and "most likely" benefits underlines a rather important point. The fact that a land disposal scheme may not pay in the Merrimack River Basin does not by any means indicate that the concept itself is faulty. If most of the estimated $6.8 million of annual benefits could be brought to bear directly on agricultural production, the land wastewater system would be quite close to paying its own way.

Lagoon areas themselves may be suitable for growing economically valuable "crops" of algae. Algae grown and harvested under controlled conditions, a process called algae stripping, purifies the water and produces a suitable livestock and poultry feed, as well as a possible substitute for fish meal.

What the effect of these beneftis will be in light of the predicted decline of the agriculture industry is unknown. A possibility is that benefiting farms will stay alive, and infact become more profitable partly as a result of the planning and thought required to make the irrigation system work.

Industry

Improvement of the quality of the Merrimack River is likely to be of limited direct benefit to industries now found in the Basin. In general, industries can use either grossly polluted water or else they can pretreat water to a degree clean enough for their needs. Over the long run, an abundance of clean water may induce a change in the character of industry in the Basin, attracting new enterprise dependent on it. Furthermore, pollution abatement, as an improvement in the quality of life, may draw an increased labor force into the benefiting area. The effects are, however, difficult to assess and not likely to be overwhelmingly important.

The net impact of pollution reduction on industry may well depend on the way such reduction is financed. If operations were supported (at least in part) by effluent charges upon users of the system, some industrial concerns would be paying a high fee indeed. Such effluent charges would distribute the costs of reducing pollution fairly among those creating it, and would provide a powerful incentive to adopting more efficient production and waste-reclamation technology.

Services and Population-Related Industries

Services, transportation, construction, finance, and the like would probably enjoy a substantial benefit during the actual construction period, reflecting a general increase in local prosperity. Such a benefit would, however, evaporate as suddenly as it had appeared, and the termination of construction would require delicate planning to minimize the impact.

Recreation and Tourism

The opportunity for boating, swimming and other water-related sports would be one of the major benefits of a clean Merrimack River. The many additional visitors attracted to the region for recreational purposes would be adding millions of dollars to the local economy. Moreover, it has been found in other areas of the United States that, in terms of dollar volume, the increase in local revenues that flows from a rise in value of taxable property is the most important result of the coming of recreation. It has been calculated that, had the Merrimack Basin been free of pollution in 1966, direct income from recreation visitors would have been $21,300,000 greater than it actually was, property values would have been higher by a total of $9,100,000, and property tax revenues would have been higher by $5,500,000. Considering that these figures are almost certainly in error in the side of conservatism, and that the demand for clean, uncrowded, accessible recreational facilities is sure to continue its steep rate of growth in years to come, it is evident that the economic impact of pollution abatement in this regard would be difficult to overestimate.

Fish and Wildlife

The abatement of pollution in the Merrimack River would make possible the re-establishment of species of anadromous fish that have virtually disappeared, including alewives, blueback herring, shad, and sturgeon. While the alewife and the blueback are not prized for food, the shad is. It should not prove too difficult to re-establish shad runs once adequate fish-ladders are built. Once shad runs were developed a valuable commercial and sport fishery would surely come into being. It may prove more difficult to reintroduce the sturgeon. However, populations of sturgeon exist in the adjacent Parker River Estuary. Thus natural re-introduction should follow the cleaning up of the River.

A more ambitious program of introduction of fish species that could bring great rewards would be the introduction of one or more species of Pacific Salmon. The most successful introductions of the Pacific Salmon have used either the Coho or the Pink Salmon. Both of these species are valuable commercially. The commercial benefit of these species would be enhanced by the fact that salmon can be fished successfully with little or no greater investment than that required for a lobster boat. In addition, a successful run of Coho Salmon would create an extremely valuable sport fishery throughout the Merrimack Valley.

Indications are that fishermen in the United States spend $10.00 per fishing trip, and that their numbers will triple between 1960 and 2000. The main stem of the merrimack River could support an additional 290,000 man-days of fishing per year.

Proper control of pollution would bring full realization of the true fish and wildlife potential of the streams. The entire Merrimack Basin lies within easy reach of highly-populated urban areas. By the year 2000, approximately 3,000,000 of the projected New England population of 17 million people will fish. An estimated 800,000 hunters will live in the area by this date. The Merrimack River would provide many additional fishing and hunting sites for these people.

The Commonwealth of Massachusetts has estimated that the annual harvest of soft shell clams is only one-twentieth of what it could be if pollution was adequately removed from the River. The yearly commercial value of soft shell clams could be $300,000 to $1,000,000.

Visual and Cultural Environment

The effects of making the Merrimack basin a more beautiful, more enjoyable region to visit and to live in, through alleviation of water pollution, are difficult to estimate, even qualitatively. However, it cannot be doubted that there are economic inplications in aesthetic improvement, principally through enhancement of the recreational experience and tourism, attracting immigration of people and businesses, and increasing land values and related tax revenues.

Land disposal of wastewater may entail negative aesthetic impacts (and, by extension, negative economic effects), if lagoons and infiltration basins prove to be unsightly or malodorous. This would, however, be balanced against the economically desirable creation of permanent greenery through irrigation. The magnitudes of these effects cannot be estimated at the present time.

SCHEME #5 - DECENTRALIZED, WATER AND LAND ORIENTED SYSTEM

This scheme implements land disposal methods, either spray irrigation for crop use and infiltration or spray irrigation for overland flow, for the municipalities of Concord, Manchester and Nashua while Fitchburg, Leominster, Lowell, Lawrence, Haverhill and the Winnipesaukee area utilize various water disposal techniques. The following discussions will delineate the ecologic, aesthetic, hygenic, social and economic impacts inherent with this particular wastewater treatment scheme.

a. Ecologic

Terrestrial

The terrestrial impacts presented by this alternative will essentially be the same as those presented in Scheme #4 - all land disposal - with the major difference being that the areas effected will not be as extensive. If the large acreages needed in the Concord-Manchester-Nashua areas are effectively managed under a multiple use concept, the benefits accruing will be great. Proper management and planning therefore will again be cricial issues in the implementation of this scheme.

For further delineation of the various terrestrial impacts inherent in this scheme refer to Scheme #4.

The major impacts to the central portion of the Basin, be they adverse or favorable, will be dependent upon the acreage needed for each disposal method and the rates of application of the secondary effluent.

Aquatic

The significant ecological aquatic impacts implicit with this scheme will manifest themselves in different stretches of the river. In the Fitchburg, Leominster, Lowell, Lawrence, Haverhill and Winnipesaukee areas, completely renovated water will now be used for purposes other than irrigation and will essentially be cycled directly into the River system. The major differences presented in this scheme can only be realized through examining the impacts that the land disposal methods have upon the water disposal methods within the same scheme. The absence of any diversion of water out of the Basin offers a guarantee of little disturbance in water flow throughout the main stem of the river although there will be site specific ramifications.

The Winnipesaukee area for example will cycle the renovated wastewater back into the River. The volume of flow reaching the Concord area will in turn not be significantly reduced. The associated adverse impacts inflicted upon the cold water communities by decreases in water volume will thereby be ameliorated. In fact, these communities will indeed be able to progress toward greater ecological stability with a more constant water volume.

The Concord-Manchester-Nashua area by implementing the various land disposal schemes will somewhat decrease the rate of flow in downstream reaches. This decrease in flow will however present only minor impacts.

Nutrient removal may not be nearly as thorough as in other schemes but in the long run this may be considered desirable since productivity potentials are dependent on receiving some nutrient load. In essence, all cold, intermediate, and warm water communities within the Basin will change favorably toward greater ecological stability.

Overall the land-water disposal combination scheme seems to offer the most beneficial impacts on all classes of the Merrimack River's ecology. One of the most important factors in coming to this conclusion is the wide spread arrangement for returning renovated wastewater to the river, thus avoiding either localized or general alteration of water volume-flow characteristics.

Estuarine

The Merrimack Estuary will experience similar impacts in each of the previous scheme. A discussion of these various impacts can be found in Scheme #4.

b. Hygienic

Since the overall situation with respect to bacteria and viruses within the Basin can best be described as one of potential health hazard, this wastewater treatment scheme will reduce the potential for incidence of water associated disease. The problems associated with the biological pathogens in the water are of major significance in this scheme since the treatment generally afforded water in the control of enteric bacterial infection is at times, not sufficient for the control of viruses. The different treatment processes, whether they be biological or physical-chemical, can not be relied upon to completely eliminate the biological pathogens in the water. Some viruses are eliminated in the coagulation, filtration and chlorination processes but more research is needed to determine their exact effectiveness.

Some viruses will pass through any given system dependent on a number of variables. For example, it is believed that during secondary treatment, approximately 90% of the polioviruses are removed but infectious hepatitis can survive. Various environmental factors such as temperature and sunlight and environmental insults such as wind and rain will determine the effectiveness of the system in removing the pathogenic organisms. Other factors such as the retention and settling time and percolation rate will play an even more vital role.

It appears that the current health hazard inherent by ingesting River water will be eliminated with the removal of enteric pathogens. Spray irrigation of crops, especially those eaten raw, can be implemented without the threat of possible bacterial contamination. Also, the shellfish beds in the Estuary can be re-established upon removal of the present bacterial contamination. Other hygienic impact of this scheme will be similar to those discussed in Scheme #4.

c. Aesthetics

The combination schemes tend to maximize the benefits both upon the River and the land. All combination schemes except this one tend to minimize specific low flow augmentation potentials. This combination scheme utilizes the land techniques in New Hampshire where the land is most useful for irrigation and the water techniques in Massachusetts which result in reduced transmission distance by eliminating transmission to Maine. This scheme does not remove the requirement for lagoons and their associated impacts in New Hampshire.

The opportunities for planning, preserving open space, and creating new open spaces are the same in this scheme as with the land scheme in New Hampshire. All the associated impacts of transmission and irrigation are also present in this scheme for New Hampshire since the system components are utilized in the same landscape context as the land scheme.

In Massachusetts the sewage treatment plants are of the same scale and location as in Scheme #1. Thus they would have minimal visual impact themselves as would the associated transmission lines. Opportunities for augmenting flow and the potential transmission lines are also similar to Scheme #1.

d. Social Opportunities

Land Use

This scheme will essentially manifest the same impacts that were presented in Scheme #4. The major difference is that the land requirements will not be as extensive - 36,000 acres VS 60,000 acres in Scheme #4.

Population

This scheme will exert similar influences on the population and future growth pattern as were presented in Scheme #4.

Leisure Opportunities

Delineation of the various leisure opportunities can be found in Scheme #4.

Municipal Services

See discussion under Scheme #4.

Institutional Involvement

This combination wastewater management scheme has a relatively low degree of institutional complexity. The subregions must develop the institutional framework to implement the system. This in itself would mean a considerable greater degree of intercommunity cooperation than now exists in these areas. In the Concord-Manchester-Nashua subregion, more intercommunity cooperation is entailed than in the other subregions. There the land disposal takes place in communities outside the jurisdiction boundaries of the subregion communities. For example in the Manchester subregion, wastewater renovation takes place as far away as Henniker and Salem.

Implementation of this wastewater management scheme would vastly improve the current situation of adjacent communities not being able to cooperate. Once they get started on a scheme of this type, it should lead to continued and more cooperation in other fields of endeavor and problems.

e. Economics

Municpial Use

See the discussion in Scheme #4.

Agriculture

The agricultural benefits derived from this Scheme will be very similar to Scheme #4. The Concord-Manchester-Nashua area will benefit to the same degree since they are set up very similar to Scheme #4. The other areas will be very similar to Scheme #1.

Industry

See the discussions in Schemes #1 and #4.

Services and Population - Related Industries

See the discussions in Schemes #1 and #4.

Recreation and Tourism

See the discussions in Schemes #1 and #4.

Fish and Wildlife

See the discussion in Scheme #4.

Visual and Cultural Environment

See the discussion in Scheme #4.

SCHEME #6 - DECENTRALIZED-ALTERNATING, WATER-LAND ORIENTED SYSTEM

This scheme calls for year round water disposal for the Lowell-Lawrence-Haverhill area while the municipalities of Fitchburg, Leominster, Concord, Manchester, Nashua and the Winnipesaukee area utilize land disposal in the summer and water disposal during the winter. Completely renovated wastewater from biological-tertiary or physical-chemical plants would be discharged to water bodies during the winter months. From mid April or early May through mid October, partially renovated wastewater from the initial treatment steps in the same plants (except Lowell-Lawrence-Haverhill), would be applied to the land by spray irrigation for final renovation. No storage lagoons are required. This scheme essentially calls for a double system - activated sludge-tertiary or physical-chemical and land for irrigation. Land requirements are however only 40% of those needed in scheme #4 - all land disposal. The following discussions will delineate the ecologic, aesthetic, hygienic, social and economic impacts inherent with this particular wastewater treatment scheme.

a. Ecologic

Terrestrial

Although the land requirements needed to implement this scheme are only 40% of those needed in Scheme #4 - all land disposal - large acreages of land will still be utilized and will produce significant terrestrial impacts. One favorable aspect of this scheme is the elimination of storage lagoons. Large areas of land will still be needed, however, and if they are effectively managed under a multiple use concept, the benefits accruing will be great. The various terrestrial effects pf this scheme are similar to those discussed extensively in Scheme #4.

Aquatic

The absence of any out of Basin water diversions offers a guarantee of little disturbance in water flow throughout the mainstem of the river especially during the winter months. There will be an insignificant decrease in flow during the summer months in reaches of the river above Lowell. This impact will only be slight and not greatly effect the cold or intermediate community organisms. In terms of ecological stability, there will be a favorable change throughout the entire basin with the removal of the pollutant load. Since the communities of Lowell, Lawrence and Haverhill will be cycling the renovated water back into the river throughout the year, fairly constant rate of flow can be expected in downstream reaches. If an anadromous fishery is to be reestablished, fairly consistent rates of flow are necessary.

Overall, the land-water combination scheme seems to offer the most beneficial impacts on all classes of the Merrimack River's ecology. One of the most important factors in coming to this assessment is the widespread arrangement for returning renovated water to the River, thus avoiding either localized or general alteration of water volume-flow characteristics.

Estuarine

See the discussion under Scheme #4.

b. Hygienic

See the discussion under Scheme #5.

c. Aesthetics

This combination scheme as well as Scheme #7 utilizes water techniques during the winter and land techniques during the summer. Therefore the lagoon system which has the greatest aesthetic impact is eliminated. Only one component of the lagoon system remains; a temporary holding lagoon which will hold secondary treated water. This lagoon will have greater potential for aesthetic improvement because its design criteria allows for flexible siting with the natural topography. The one exception to the summer/winter combination is in Lowell-Lawrence-Haverhill where there is year round utilization of water techniques. This also eliminates lagoons and provides potential for altering flow characteristics utilizing numerous discharge points.

Non-regionalization of treatment plants in this scheme provides for minimal visual impact to the specific site locations. It also increases the potential for guiding growth within the regions utilizing transmission lines as well as irrigation sites. Transmission lines are reduced in this scheme to a length where their potential for a positive visual impact by providing visual and physical access is maximized.

d. Social Opportunities

Land Use

This scheme offers similar impacts on land use to Scheme #4. The major difference is that the land requirements are less, 24,500 acres.

Population

See the discussion under Scheme #4.

Leisure Opportunities

See the discussion under Scheme #4.

Municipal Services

See the discussion under Scheme #4.

Institutional Involvement

This wastewater management system demands a high degree of cooperation within subregions but little is demanded between subregions. Certainly the use of land in another jurisdiction for renovation demands a great deal of cooperation. Surely if communities can work together to solve the problems of waste, then they can work together to solve other problems. The system does not involve crossing of state boundaries so one element of jurisdictional cooperation is not achieved by this alternative. The degree of regional integration is such that managerial savings should be realized with the proper cooperation.

Community Image

See the discussion under Scheme #4.

e. Economics

Municipal Use

See the discussion under Scheme #4.

Agriculture

The discussion under Scheme #4 delineates the agricultural impacts except that only 24,500 acres are involved in this scheme.

Industry

See the discussions with Schemes #1 and #4.

Services and Population Related Industries

See the discussion under Scheme #4.

Recreation and Tourism

See the discussion under Scheme #4.

Fish and Wildlife

See the discussion under Scheme #4.

Visual and Cultural Environment

See the discussion under Scheme #4.

SCHEME #7 - CENTRALIZED-ALTERNATING WATER-LAND ORIENTED SYSTEM

This scheme integrates both water and land disposal methods. Completely renovated wastewater, will be discharged directly to water bodies during the winter months. From mid April or early May through September or mid October, partially renovated wastewater from the initial treatment process, coagulation-sedimentation, would be applied to the land by spray irrigation for final renovation. No lagoons are needed. Two large regional physical-chemical facilities would serve the six urban areas, one plant would be located just north of Concord and the other would be west of Lowell. The following discussions will delineate the ecologic, aesthetic, hygienic, social and economic impacts inherent with this particular wastewater treatment scheme.

a. Ecologic

Terrestrial

One of the more significant changes presented with this scheme is the elimination of the various storage lagoons. Since this scheme implicates a large degree of regionalization, transmission lines could present more of an unfavorable impact if not carefully planned and constructed. The land areas will not be as extensive as those needed' in the all land disposal scheme but will still present significant impacts.

For further discussion of the various terrestrial ecologic impacts associated with this scheme, refer to Scheme #4.

Sludge Disposal

Refer to Scheme #3.

Aquatic

The point should be made that the effluent produced by the physical-chemical system and recycled back into the river during the winter months may be too low in nutrient value. In essence, some pollution in the natural system is beneficial to the health and productivity of the River ecosystems and removal of all pollutants could have some adverse repercussions. This scheme also has inherent disadvantages due to the high degree of regionalization. During the winter months of non-irrigation, the scheme would have only two major points of renovated water discharge unless the effluent is pumped to different locations in the basin. The overall system will have a favorable impact on the ecological stability of the cold, intermediate and warm water communities of the river. Volume of flow will be enhanced during the winter months and only slightly decreased during the summer irrigation periods.

Estuarine

Refer to Scheme #4 for discussion.

b. Hygienic

Problems could be presented during the incineration of sludge if available controls suitable for reducing particulate emissions to acceptable levels are not effectively utilized. The discharge of harmful gases with the possibility of incorporating deleterious trace elements into the food chains of various organisms needs to be more extensively researched.

For other hygienic considerations see the discussion in Scheme #5.

c. Aesthetics

All the primary aesthetic impacts of increased water quality and quantity will be introduced to the River with this scheme. It will also have the associated aesthetic impacts of Scheme #3 and the impacts of the land scheme (Scheme #4). Thus this combination as do the other two combinations tends to maximize potential impacts to the River and to the land.

The regionalization of this plan provides greater potential for impact of transmission lines as well as treatment plants. Two regional physical-chemical plants will be of necessity, large in scale. Their impact, positive or negative, will be determined by the innovation of their design. Likewise, impacts of transmission lines will have greater potential because of extended length.

Since this scheme totally integrates summer/winter techniques, it too, like Scheme #6 eliminates the lagoon system leaving only a 10 day holding lagoon. These lagoons will be larger than the holding lagoons of Scheme #6 and therefore more difficult to work into the natural contours. However, the storage water quality will be the same as Scheme #6 and with effective management not likely to have any objectionable consequences.

Visual impacts of spray irrigation - infiltration and overland flow sites will be similar to those of Schemes #4, #5 and #6. Planning opportunities using irrigation areas will also be the same, but planning control among regions will be enhanced through greater regionalization of the systems.

d. Social Opportunities

Land Use

This scheme will produce much the same land use impacts as Scheme #4 except that only 39,000 acres are involved.

Population

See the discussion with Scheme #4.

Institutional Involvement

Implementation of this wastewater management scheme will achieve a high degree of intergovernmental cooperation. This will be achieved at the town county and state levels. Here with all waste flows being handled by two plants, all governmental levels must work together to achieve a functional system. Summer land disposal entails using land outside the jurisdictional boundaries of the cities and towns served by the system. In this part of the system, the complexity of the institutional arrangements becomes even greater. This can serve many purposes but one of the first that appears is that if these communities can be shown that cooperation in wastewater management can bring about good results, what can be achieved in other problem areas by cooperation.

Community Image

Refer to the discussion with scheme #4.

Leisure Opportunities

See the discussion with Scheme #4.

Municipal Services

See the discussion with Scheme #4.

e. Economics

Municipal Use

See the discussion with Scheme #4.

Agriculture

The discussion under Scheme #4 covers the major points. In this scheme the amount of land involved changes to 39,000 acres.

Industry

See the discussion with Scheme #4.

Services and Population - Related Industries

See the discussion with Scheme #4.

Recreation and Tourism

See the discussion with Scheme #4.

Fish and Wildlife

See the discussion with Scheme #4.

Visual and Cultural Environment

See the discussion with Scheme #4.

CHAPTER D. RESEARCH NEEDS

A thorough analysis of the impact of the various wastewater management schemes has been constrained in this effort by deficiencies in time and knowledge. A more complete understanding can be achieved with additional studies in the areas of ecology, hygiene, aesthetics, sociology and economics. The needs for research in these areas is outlined in the following sections.

1. ECOLOGY

In order to adequately predict changes to the ecology of the Merrimack River Basin resulting from a wastewater management scheme, a better picture of the baseline ecology is necessary. This can be broken into five areas:

1. Terrestrial vegetation of the Basin.
2. Terrestrial wildlife of the Basin.
3. Aquatic flora
4. Aquatic fauna
5. Survey of the physical and chemical properties of streams , in the Basin.

There is also a need for certain basic questions to be answered. Some of these questions are:

1. What are the temperature and salinity tolerances of a number of shellfish predators which might invade the estuary subsequent to the removal of pollutants?

2. At what rate will a grossly polluted clam flat cleanse itself?
3. How long would the various soils of the Merrimack Basin continue to be effective in adsorbing and holding heavy metal ions?
4. How much change in the water regimen can various species of trees tolerate?

2. HYGIENE

A great deal of study must be done in the area of hygiene before any system can be relied on to assure safety to the populous. The real questions hinge on how are enteric viruses best inactivated. Considerable research needs to be done on the effectiveness of the land and water systems in inactivating various viruses. Undoubtedly, considerable research is underway at the present time, to answer these questions.

Also in this same vein, more needs to be known about the tolerance levels and effects of various heavy metals.

3. AESTHETICS

A determined effort must be made to analyze the visual aspects and implication of wastewater management in the Merrimack River Basin. In line with this effort the following studies should be made:

1. A determination of the preferred Merrimack landscapes and riverscapes.
2. Determinations of the physiographic and visual setting of each site under consideration.
3. Studies of wind patterns and potential effects of odor and humidity to areas surrounding wastewater management sites.

4. An investigation of the integration of transmission lines with recreation corridors, urban pathways, development control, highways, railroads, etc.

With these studies a full analysis of any wastewater management system can be made.

4. SOCIAL OPPORTUNITIES

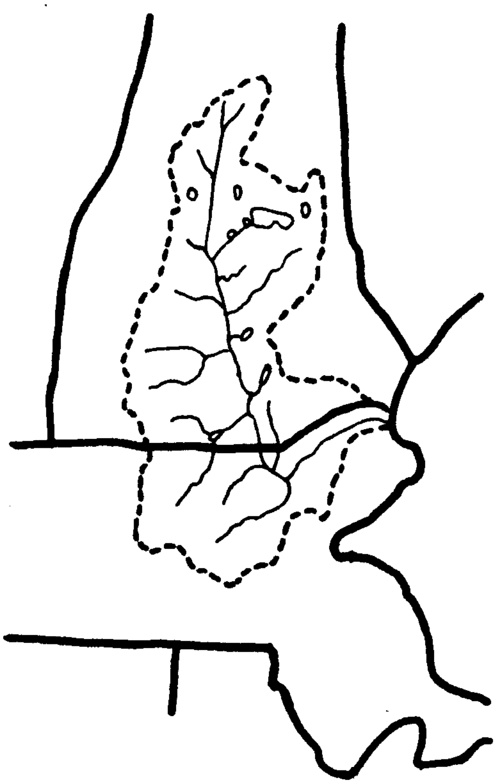
Under the category of social opportunities there are several determinations that should be made in connection with wastewater management. Most of these determinations come under the categories of needs or public acceptance. The determination of needs include recreational needs of the urban and rural areas of the Basin and the water supply demand of the communities of the Basin. Under public acceptance come the considerations of recycling of water, transporting of sewage long distances and complex administrative units to manage wastewater. These are some of the points that, if fully analyzed, will go a long way to making a full social opportunities analysis.

5. ECONOMICS

In the field of economics, the major need is for refinement of the benefits of wastewater management. More research is needed to define the benefits of wastewater management to agriculture in the Merrimack Basin, to industry, to goods and services, and to the recreational industry. As pointed out in Chapter C, there is considerable potential for benefits in the Merrimack River Basin, but at this point in time hard values cannot be placed on these benefits.

THE MERRIMACK:

DESIGNS FOR A CLEAN RIVER



EVALUATION OF IMPACTS OF SELECTED ALTERNATIVES

APPENDIX V

AUGUST 1971

THE MERRIMACK: DESIGNS FOR A CLEAN RIVER

A

FEASIBILITY STUDY

FOR

WASTEWATER MANAGEMENT

IN THE

MERRIMACK RIVER BASIN

APPENDIX V

EVALUATION OF IMPACTS OF SELECTED ALTERNATIVES

TABLE OF CONTENTS

	Page
CHAPTER A. INTRODUCTION	V-A-1
CHAPTER B. THE SCHEMES	
1. CURRENT EPA-STATE WASTEWATER TREATMENT PROGRAM	
a. Environmental Quality	V-B-1
b. Social Well-Being	V-B-2
c. Regional Development	V-B-4
d. National Economic Development	V-B-5
2. SCHEME #1 - DECENTRALIZED, WATER ORIENTED SYSTEM	
a. Environmental Quality	V-B-7
b. Social Well-Being	V-B-9
c. Regional Development	V-B-11
d. National Economic Development	V-B-12
3. SCHEME #2 - PARTIALLY DECENTRALIZED WATER ORIENTED SYSTEM	
a. Environmental Quality	V-B-14
b. Social Well-Being	V-B-16
c. Regional Development	V-B-19
d. National Economic Development	V-B-20
4. SCHEME #3 - CENTRALIZED WATER ORIENTED SYSTEM	
a. Environmental Quality	V-B-21
b. Social Well-Being	V-B-23
c. Regional Development	V-B-25
d. National Economic Development	V-B-26
5. SCHEME #4 - DECENTRALIZED, LAND ORIENTED SYSTEM	
a. Environmental Quality	V-B-28
b. Social Well-Being	V-B-30
c. Regional Development	V-B-32
d. National Economic Development	V-B-33
6. SCHEME #5 - DECENTRALIZED WATER AND LAND ORIENTED SYSTEM	
a. Environmental Quality	V-B-35
b. Social Well-Being	V-B-37
c. Regional Development	V-B-39
d. National Economic Development	V-B-40

TABLE OF CONTENTS (con't)

	Page
7. SCHEME #6 - DECENTRALIZED-ALTERNATING, WATER AND LAND ORIENTED SYSTEM	
a. Environmental Quality	V-B-42
b. Social Well-Being	V-B-44
c. Regional Development	V-B-46
d. National Economic Development	V-B-47
8. SCHEME #7 - CENTRALIZED ALTERNATING, WATER AND LAND ORIENTED SYSTEM	
a. Environmental Quality	V-B-49
b. Social Well-Being	V-B-51
c. Regional Development	V-B-53
d. National Economic Development	V-B-54

CHAPTER A - INTRODUCTION

In Appendix IV the impacts of the various wastewater management schemes on the ecologic, hygienic, aesthetic, social opportunity and economic characteristics of the Merrimack River Basin were identified. Appendix V is an evaluation of the effects and consequences of these identified impacts.

The Objectives

In an effort to make resource planning a more comprehensive analysis, four broad objectives have been recommended to the United States Water Resources Council. These objectives are:

Environmental Quality

Social Well-Being

Regional Development

National Economic Development

These objectives form the basis for evaluation of the effectiveness of the various wastewater management schemes. The objectives are defined in the following paragraphs.

Environmental Quality involves the preservation, management or enhancement of water, land and related resources and amenities that have ecological, cultural, aesthetic or other values that make them significant.

Social Well-Being involves the equitable distributions of real income, employment opportunities and populations, with special concern for the incidence of the consequence of a plan on affected persons or groups; contributing to the security of life and health; providing educational, cultural, and recreational opportunities.

Regional Development has an objective to improve income, employment, economic base, environment, and social well-being of a region.

The National Economic Development objective is to increase the value of the Nation's goods and services and to improve the national economic efficiency.

The Objectives and Wastewater Management

The four broad objectives must be applied to the specifics of Wastewater Management. In this Appendix the impacts identified in Appendix IV will be related to each of the four broad objectives. The effects and consequences of the various wastewater management schemes will be related to the overall objectives of resource planning in order to gain an understanding of the accomplishments and shortcomings of each scheme.

The evaluation presented here highlights the major accomplishments and shortcomings of each scheme in relation to each objective. The evaluation that follows does not assign monetary values to benefits and costs since data which would enumerate these values does not exist. The capital costs of each scheme is by far the firmest figures in the evaluation.

Table 1 presents a synopsis of the detailed evaluation given in Chapter B.

TABLE 1

MERRIMACK WASTEWATER MANAGEMENT STUDY — EVALUATION OF IMPACTS					SCHEMES PRESENTED IN THIS REPORT						
OBJECTIVES		**Uniform for all Eight Solutions**	**EPA-State Implementation Program**	**Common to all Seven Schemes**	**Scheme 1**	**Scheme 2**	**Scheme 3**	**Scheme 4**	**Scheme 5**	**Scheme 6**	**Scheme 7**
Environmental Quality	BENEFITS:	Considerable increase in benthic organisms, fishery resources, birds, and waterfowl; Establishment of additional species of plants and animals.	Favorable effect upon species diversity and ecosystem stability; Significant improvement in clarity, odor and taste of Merrimack River Water.	Very favorable effect upon specie diversity and ecosystem stability in the rivers; great improvement in clarity, color, odor, and taste of Merrimack water; Reduced potential of algae problem.		Along transmission pipe routes landscape diversity may increase and wildlife habitat may improve.	Along many miles of transmission pipe routes landscape diversity may increase and wildlife habitat may improve.	Along very many miles of transmission pipe routes landscape diversity may increase and wildlife habitat may improve; considerable acreage remains semi-natural.	Same as Scheme 4 except moderate acreage remains semi-natural.	Same as Scheme 5	Same as Scheme 5
	COSTS:	Some degradation in terrestrial ecology near plant sites.	Potential of Algae problem.		Some temporary disturbance of scenery and permanent disturbance of terrestrial ecology.	Same as Scheme 1; moderate disruption of scenery by transmission pipe routes.	Same as Scheme 1 over greater area; significant disruption of scenery by transmission pipe route; considerable reduction of flow in Nashua River.	Same as Scheme 3; extensive disruption of natural conditions by lagoons and land disposal areas; possible damage to pitch pines and to forest duff; possibility of spreading pathogens through waterfowl on lagoons.	Same as Scheme 4, except no flow loss in Nashua River.	Same as Scheme 3, except no flow loss in Nashua River; moderate disruption of natural condition in land-disposal areas; possible damage to pitch pine and forest duff.	Same as Scheme 3; significant disruption of natural conditions in land disposal areas.
Social Well-Being	BENEFITS:	Increased availability of cleaner water; reduction in bacterial pollution with general public health benefits	Considerable enhancement of potential for water recreation; Improvement of Merrimack as a water source; Provision of a better and more attractive place in which to live.	Great enhancement of potential for water recreation; Further improvement of the Merrimack as a water source; Provision of better, more attractive place to live which will raise community pride and attract people.	Provide for limited cooperation between communities and states; development potential for multiple use of wastewater facilities.	Provide for some cooperation between communities and states; develops potential for multiple use of wastewater facilities.	Provide for considerable cooperation between communities and states; develop large potential for multiple use of wastewater facilities.	Same as Scheme 3	Provide for some cooperation between communities and states; develop large potential for multiple use of wastewater facilities.	Same as Scheme 5	Same as Scheme 3
	COSTS:	Possible increase in demand for services from additional population.						Land disposal areas may be unsightly and may increase the number of insects.	Same as Scheme 4	Same as Scheme 4	Same as Scheme 4
Regional and National Economic Development	BENEFITS:	Increase of commercial enterprises catering to recreationists.	Industry will benefit; Land values and development will be affected and the tax base of river towns will rise; Long run employment could increase; finfish industry will be significantly improved.	Industry will benefit markedly; Land values will be significantly affected; Land development and land planning will be greatly affected; The tax base will rise; Long and short term employment will increase; Local flooding will be greatly reduced; Finfish industries will be greatly improved. Sport fishing industry will grow rapidly.	Some nutrients will be provided by sludge.	Same as Scheme 1		Large scale use of waste water in crop production; Improvement in quality and quantity of timber; nutrients will be provided by sludge.	Same as Scheme 4	Same as Scheme 4	Large scale use of wastewater in crop production; improvement in quantity of timber.
	COSTS:		Local taxes may rise.	Local taxes may rise.							

CHAPTER B. - THE SCHEMES

1. CURRENT EPA - STATE WASTEWATER TREATMENT PROGRAM

a. Environmental Quality

The environmental quality of the Merrimack will be modestly improved by the implementation of secondary treatment facilities. The following items indicate the areas and degree of benefit and cost.

Ecologic

1. The fishery resource in the warm water portion of the Merrimack Basin will be slightly enhanced.
2. In the intermediate water temperature portion of the basin, the fishery resource will be somewhat degraded.
3. The diversity of benthic organisms in the Merrimack and Nashua Rivers will be considerably enhanced.

Hygienic

1. Bacterial contamination of the rivers of the Merrimack Basin will be considerably lessened.
2. Fish in the Merrimack River will be somewhat safer to eat from the standpoint of bacterial contamination. The build-up of heavy metals however poses a threat that must be monitored.

Aesthetics

1. The improved clarity of the Merrimack River will make it more visually appealing.
2. Odors emanating from the River will be somewhat reduced.

Social Opportunities

1. Beaches on the Merrimack River may be opened.
2. The sport fishery of the Merrimack River will be somewhat aided.

3. Waters acceptable for recreational boating will be increased slightly.

4. The Merrimack River will be considerably improved as a source of water.

Economics

1. Recreation and related services will likely improve to some small degree.

2. There will be a moderate increase in sport fishing.

b. Social Well-Being

In terms of social well-being the residents of the Merrimack Basin will be somewhat better off as a result of this program. The following points show why:

Ecologic

1. Slight improvement of the fishery will make the rivers more enjoyable.

2. There will be significant degradation of the terrestrial ecology at the plant sites.

Hygienic

1. Fish caught in the Merrimack River will be somewhat safer to eat from the standpoint of bacterial contamination but the heavy metals will still enter in the food chain if proposed sewer ordinances are not effective.

2. Crops irrigated with water from the Merrimack will be safer to eat from the standpoint of bacterial contamination but the heavy metals will enter, if proposed sewer ordinances are not effective.

3. Water supplies will be of somewhat higher quality.

4. The health risk of water-based recreational activities on the river will be somwehat lessened.

5. Viruses are not effectively neutralized or removed by this system of treatment.

Aesthetics

1. Rivers of improved clarity will be more visually appealing.

2. Odors emanating from the rivers will be reduced slightly.

3. Water drawn from the Merrimack will have improved taste qualities.

4. Treatment plants will or will not be unsightly depending on the care taken in the design.

Social Opportunities

1. Some beaches on the Merrimack River may be reopened.

2. Sport fishing will be somewhat aided.

3. The amount of water in the Basin available for recreational boating will be increased.

4. Available water supply will be somewhat enhanced by bringing the Merrimack River nearer to a quality set by the Public Health Service for raw drinking water.

5. A somewhat cleaner Merrimack River will likely attract some new residents.

6. The river cities, Fitchburg, Leominster, Lowell, Lawrence, Haverhill, Nashua, Manchester, and Concord will become somewhat more attractive.

7. The program is a small step in bringing about involvement and cooperation for mutual benefit between towns.

Economics

1. The recreation and related service industries will benefit.

2. Land values along the Merrimack River will increase slightly with a corresponding tax base increase.

3. Recreational boating in the Basin should improve.

c. Regional Development

This program will aid the development of the Merrimack River Basin as shown in the following sections:

Ecologic

1. The available fishery resource in the Merrimack Basin will increase slightly.

Hygienic

1. Irrigation of vegetable crops with water from the Merrimack River will continue with a slight decrease in risk to public health.

2. Water related recreational activities on parts of the River can be permitted to increase.

Aesthetics

1. The rivers will become somewhat more attractive in the Basin.

Social Opportunities

1. Some beaches on the Merrimack River can be opened.

2. Available sport fishing will increase slightly on the Merrimack.

3. New residents will likely be attracted to the rivers.

4. A step is taken towards community involvement.

Economics

1. The recreation and related service industries will be somewhat enhanced.

2. Land values along the rivers will be somewhat enhanced with a resultant increase in the tax base.

3. Travel distance to water-based recreation sites will be considerably reduced.

4. The recreational boating industry in the Basin should benefit.

d. National Economic Development

Full implementation of this program will aid the economic development of the nation as outlined here, although this is not to the extent of regaining the capital cost of implementation.

Ecologic

1. The fishery resource in the Merrimack Basin will increase to a slight degree.

Hygienic

1. Irrigation of vegetable crops with Merrimack River water will continue with lower risk to human health.

2. Water-contact recreational activities can be resumed in some parts of the Merrimack River.

Aesthetics

1. There will be a increase in the attractiveness of the rivers in the Basin.

Social Opportunities

1. New residents will likely be attracted to the rivers.

2. A small step is taken towards greater community cooperation and involvement.

Economics

1. Property values along the main stem of the rivers will increase slightly.

2. The tax base will somewhat improve in riverfront communities.

3. The recreational goods and services industry will be enhanced to a slight degree.

4. The sport fishery and its multiplying services and products will benefit slightly.

5. The threat of closure of the Merrimack as a source of irrigation water will be minimized.

6. Travel distance to available water-based recreational facilities from the Boston Metropolitan Area will be decreased.

2. SCHEME #1 - DECENTRALIZED, WATER ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, the air, and their related resources. The following points will depict specific ecologic, hygenic, aesthetic, sociologic and economic changes associated with this wastewater management scheme.

Ecologic

1. Sludge disposal on the land will provide a source of plant nutrients.
2. Incorporation of the sludge in the soil will enhance soil moisture holding capacity and water infltration rates.
3. In the long-run, nutrients (mercury, boxon, zinc, etc.) contained within the sludge might accumulate within the soil, to a point where they exceed the tolerance limits of the plants, or soil microorganisms if there is not proper management.
4. The land and vegetation in various areas will be severely disrupted by construction.
5. Removal of the pollutant load from the River should encourage the establishment of additional species of plants and animals in all segments of the River and Estuary.
6. Piping renovated water into Lake Winnisquam will retard the present rate of eutrophication.
7. Increased stream flow in small streams caused by cycling renovated water will encourage fish establishment and development.
8. Renovated wastewater cycled through lakes or streams would adversely affect the temperature and disolved oxygen content of the water body near the outfall point. This would negatively shift the biologic stability of some organisms near the outfall point.

9. Anadromous fish could be re-established in the River with proper fish ladders.

10. Diversity of benthic organisms in the Merrimack and Nashua Rivers will be considerably enhanced.

Hygienic

1. Treatment facilities will reduce the quantity of viruses, bacteria and toxicants now present in the River.

2. Sludge placed on the land and not immediately incorporated into the soil may provide favorable insect breeding habitats.

3. Reduction in the number of bacteria and viruses in the Merrimack River will enhance the quality of agricultural crops irrigated with the River water.

Aesthetics

1. The River will have greater clarity and less floating and suspended solids; thus it will have more visual appeal.

2. Odors arising from decomposition of organic matter within the River will be reduced.

3. Withdrawals from the River for water supply will have a better taste.

4. Well landscaped treatment facilities will provide green open areas available to public access.

5. Sludge spread on the land and not immediately incorporated will be visually disdainful.

6. Disposal of sludge on public lands, (parks, roadsides, gold courses, and etc.) may not be acceptable to the populace.

7. Increased tourism will reduce environmental quality in high use areas.

Social Opportunities

1. Reduction in the pollutant level of the river will permit increased safe public access and use of the river with a concomitant development of recreational areas and associated commercial activities.

Economic

1. Creation of quality recreational areas on the River will increase tourism.

2. Establishment of anadromous fish will create sport and commercial fisheries.

3. Sludge disposal on land used for crop production will decrease fertilizer requirements while enhancing soil structural characteristics conducive to plant growth.

4. Development of property adjacent to the "clean" River will disrupt terrestrial and aquatic habitats.

5. Placement of water renovation facilities on the dilapidated waterfront will enhance domestic environmental quality of the area.

6. Seasonal tourist impact would undoubtedly be a detriment to the existing "natural habitats".

7. Shellfish predators could become re-established in the Estuary.

8. Increased numbers of waterfowl will enhance sporting activities near the Estuary.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focun on the changes resulting from implementation of this scheme and the related effects these changes have on the Basin populace.

Ecologic

1. Improvement of Lake Winnisquam and the Merrimack River will enhance their sport fishing and recreational potential.

Hygienic

1. Decrease in bacteria and viruses in the Merrimack will greatly reduce the possibility of infection and disease.

2. Crops irrigated with Merrimack water will be safer for human consumption.

3. The possibility of diseases stemming from recreational activities associated with the River will be greatly reduced.

4. The increase in seasonal and permanent human population may create health and sanitary problems during periods of maximum human influx.

Aesthetics

1. Treatment facilities will create open spaces with multi-use capabilities.

2. Facilities located in urban waterfronts may provide local residents recreational and relaxation areas.

3. The visual and odor characteristics of the River will be improved.

4. Transmission lines to the local treatment facilities will disrupt the scenic qualities of the landscape during construction.

5. People will be attracted to the Basin by the improved scenic qualities of the River.

Social Opportunities

1. Treatment facilities can provide multiple-use areas available to the public.

2. Sludge disposal on public lands is not expected to deter public use if sludge application is correlated with annual periods of low or no public use.

3. The population increase during the construction phase may strain existing municipal services.

4. Open areas along transmission lines will provide increased habitat for wildlife.

5. Beaches on the Merrimack River will be reopened.

6. Sport fishing will be greatly aided throughout the River, the Estuary and Lake Winnisquam.

7. A clean River will attract new residents, both permanent and seasonal, to the recreational River opportunities.

8. The image and pride of river cities will be heightened by a clean attractive river.

9. Governments of River communities will cooperate in development, installation, and maintenance of the common treatment facilities.

Economics

1. Unemployment during the construction of this scheme will be substantially reduced.

2. Business and services related to tourism and outdoor recreation will increase.

3. Commercial fishing opportunities related to an increase in the shellfish and anadromous fish populations will be augmented.

4. Those communities which rely on the River for water supply will experience decreased water supply costs.

c. Regional Development

Regional development involves increases in a regions income, employment, and overall improvement of their economic base, environment, public health, social aspects, and aesthetic attributes of the area.

Ecologic

1. Available fishery resources in the Merrimack Basin will increase substantially.

Hygienic

1. Irrigation of crops using Merrimack River water will continue without the threat of bacterial contamination.

2. Water related recreational activities on the River will increase.

3. A source of clean water will be readily accessible.

Aesthetics

1. The attractiveness of the River will be enhanced.

Social Opportunities

1. Beaches on the Merrimack can be reopened.

2. Sport fishing will increase on the Merrimack River and the Estuary.

3. Governments of towns using the treatment plants will become involved with each other.

4. Construction of each facility could create stresses on existing municipal services.

Economic

1. Increased recreation and related commercial enterprises will enhance the region.

2. Land values adjacent to the River will increase substantially.

3. Land values near treatment facilities and collection apparatus may be proportionally lower.

4. Overall land values of the River communities should increase.

5. The capital investment of this scheme will be approximately $876 million. The annual cost will be $96 million.

d. National Economic Development

National economic development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The fish and shellfish industries will be enhanced in the Merrimack River and Estuary.

2. Sludge used as fertilizer and higher quality River water could increase crop production.

Hygienic

1. Public health will be enhanced by a clean River.

Social Opportunities

1. Recreational opportunities will be significantly encouraged.

Economic

1. Tourism and commercial and recreational activities will increase income.

2. Tax base of River communities will increase.

3. Industry and production will be enhanced.

4. The capital investment in the six regional facilities, which comprise this scheme will be approximately $876 million. Annual cost of these facilities will be $96 million.

3. SCHEME #2 - PARTIALLY, DECENTRALIZED WATER ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, the air, and their related resources. The following points will depict specific ecologic, hygienic, aesthetic, sociological, and economic changes associated with this wastewater management scheme.

Ecologic

1. Sludge disposal on the land will provide a source of plant nutrients.

2. Incorporation of the sludge into the soil will enhance the soil moisture holding capacity and water infiltration rates.

3. In the long run, nutrients (Magnesium, Boron, Zinc, etc.) contained within the sludge might accumulate in the soil to the degree where they exceed the tolerance limits of plants, or soil microorganisms if there is not proper management.

4. The land and vegetation in the vicinity of the four treatment facilities will be severely disrupted.

5. Removal of the pollutant load will allow the establishment of additional species of plants and animals in all segments of the River and the Estuary.

6. Diversion of renovated wastewater outside the Basin will severely alter the aquatic habitats in the lower reaches of the River.

7. A water temperature increase and dissolved oxygen decrease during times of low flow would produce a stress situation on aquatic organisms.

8. Water diversion outside the Basin would all but stop fresh water flow into the Estuary during periods of low flow.

9. Reduction in streamflow would adversely affect the re-establishment of anadromous fish.

10. Piping renovated water into Lake Winnisquam would alleviate the present eutrophic conditions.

11. Changes in streamflow of small streams caused by cycling renovated wastewater will encourage fishery development.

12. Treated water cycled into water bodies would adversely affect the temperature and dissolved oxygen content of the water near the outfall point. This would shift the biologic stability of some organisms near the outfall plant.

13. The diversity of benthic organisms in the Merrimack and Nashua Rivers will be considerably enhanced.

14. There will be increased wildlife habitat along the transmission lines.

15. The number of waterfowl and shore birds frequenting the Estuary during migration will increase as food organisms respond to reduced pollution.

16. Development of property adjacent to the "clean" River will disrupt terrestrial and aquatic habitats.

17. The seasonal tourist influx would undoubtedly be to the detriment of the existing "natural habitats".

Hygienic

1. Treatment facilities will reduce the viruses, bacteria and toxicants in domestic and industrial wastewater returned to the River.

2. Sludge placed on the land and not immediately incorporated into the soil may provide favorable insect breeding habitats.

3. Reduction in the numbers of bacteria and viruses in the Merrimack River will reduce the health hazard.

Aesthetics

1. The River will have greater clarity and thus will be more visually appealing.

2. Odors arising from decomposition of organic matter within the River will be reduced.

3. Withdrawals from the River for water supply will have a better taste.

4. Well landscaped treatment facilities will provide green open areas available to public access.

5. Sludge spread on the land and not immediately incorporated will be visually disdainful and may result in offensive odors.

6. Diversion of water during low flow would result in exposure of large portions of stream bottom. Dehydration of aquatic plants attached to the stream bottom would detract from scenic attributes of the River.

7. During summer periods of low flow portions of the River may resemble shallow ponds, in that they will contain large algae growths and emit "swampy" odors.

Social Opportunities

1. Reduction in the pollutant level of the River so as to permit safe public access and use of the River will encourage development of recreational areas and associated commercial activities.

2. Placement of water renovation facilities on the urban waterfront will enhance the domestic environment of the area.

Economic

1. Establishment of high quality recreational areas on the River will increase tourism.

2. Establishment of anadromous fish will create sport and commercial fisheries.

3. Sludge disposal on land used for crop production will decrease fertilizer requirement while enhancing soil structural characteristics conducive to plant growth.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on the changes resulting from implementation of this scheme and the related effects these changes have on the Basin populace.

Ecologic

1. Well landscaped and maintained treatment facility areas which are accessible to the public will provide park-like areas.

2. There will be improvement of Lake Winnisquam waters as the rate of eutrophication is reduced.

3. There will be a decrease in the available water supply in the lower Merrimack River by any water diversion outside the Basin.

4. Removal of domestic and industrial wastes from the slow flowing Nashua River will alleviate some of the existing eutrophic conditions.

5. Shellfish predators may become re-established in the Estuary.

6. There will be an increase in the number of waterfowl and shorebirds frequenting the Estuary.

<u>Hygienic</u>

1. The decrease in bacteria and virus in the Merrimack will greatly reduce the possibility of infection and disease.

2. Crops irrigated with Merrimack River water will exhibit a significant reduction in the number of bacteria.

3. Recreational activities associated with the River will be greatly enhanced.

4. Increase in seasonal and permanent population may create health and sanitary problems during periods of maximum influx.

<u>Aesthetics</u>

1. Visual and odor characteristics of the River will be improved.

2. The larger treatment facilities will prove a greater visual impact.

3. Transmission lines to the regional facilities will disrupt the scenic qualities of the landscape.

4. Open spaces and multi-use capabilities of treatment facilities will be created.

5. Facilities located in urban waterfronts can provide residents recreation and relaxation areas.

6. People will be attracted to the Basin by the scenic qualities of the River.

Social Opportunities

1. Treatment facilities can provide multiple use areas available to the public.

2. Sludge disposal on public lands is not expected to deter public access if sludge application is correlated with annual periods of little or no public use.

3. Population increase during the construction phase may strain existing municipal services.

4. Beaches on the Merrimack River will be reopened.

5. Sport fishing will be greatly aided in Lake Winnisquam, the upper portion of the Merrimack River, and the Estuary.

6. Open areas along transmission lines will provide increased habitat for wildlife.

7. A high degree of cooperation will have to be attained between the various Basin communities.

8. Public water supply within the Basin will be reduced by any diversion of water to southeastern New Hampshire.

9. A large portion of the Merrimack River will be available for water recreation.

10. A clean River will attract new residents, both permanent and seasonal.

11. The image and pride of River cummunities will be heightened by a clean attractive River.

12. Governments of River communities will have to cooperate in development, installation, and maintenance of the common treatment facility.

Economic

1. Unemployment during construction of the facilities will be substantially reduced.

2. Businesses and services related to tourism and outdoor recreation will increase as the recreation potential of a clean River is realized.

3. Income opportunities related to shellfish and anadromous fish will be augmented.

4. Present and future cost of domestic water will decrease in those communities relying on the River for their water supply.

c. Regional Development

Regional development involves increases in a regions income, employment, and overall improvement of their economic base, environment, public health, social aspects, and aesthetic attributes of the area.

Ecologic

1. The available fishery resources in the Merrimack Basin will increase substantially.

Hygienic

1. Irrigation of crops using Merrimack River water will continue with reduced health hazard.

2. Water related recreational activities on the River will increase.

3. Clean water will be more accessible.

Aesthetics

1. The attractiveness of the River will be enhanced.

Social Opportunity

1. Beaches on the Merrimack can be reopened, which will encourage recreational activities.

2. Available sport fishing will increase on the Merrimack River and the Estuary.

3. Construction of each facility could create stresses on existing municipal services.

Economic

1. Recreation and related commercial enterprises will be enhanced.

2. Land values adjacent to the River will increase substantially as recreational benefits are realized.

3. Land adjacent to treatment facilities and collection apparatus may have a lower value.

4. Overall land values of the River communities should increase.

5. Capital investment for this scheme will be $877 million, with an annual cost of $95 million.

d. National Economic Development

National economic development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The fish and shellfish industries will be enhanced in the Merrimack River and Estuary.

Hygienic

1. Public health will be enhanced by a clean River.

Aesthetics

Social Opportunities

Economic

1. Tourism and recreational opportunities will be significantly encouraged.

2. Crop production will be encouraged by use of sludge to reduce fertilizer cost and continued use of River water for irrigation.

3. Tax base of River communities will improve.

4. Industry and production will be enhanced.

5. The capital investment for this scheme will be $877 million. Annual cost will be $95 million.

4. SCHEME #3 - CENTRALIZED, WATER ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies preservation or enhancement of the water, the land, the air, and their related resources. The following points will depict specific ecologic, hygienic, aesthetic, sociological and economic changes associated with this wastewater management scheme.

Ecologic

1. Incineration of sludge may result in noxious gases, particulate or heavy metal oxides being emited into the air.

2. If there is not proper management, land disposal of sludge may accumulate nutrients (Mercury, Boron, Zinc, etc.) within the soil so they may exceed the tolerance limits of the plants on soil microorganisms.

3. The land and vegetation at the two regional treatment plant sites and along the needed transmission lines will be severely disrupted.

4. Removal of the pollutant load from the River should encourage the establishment of additional species of plants and animals in all segments of the River and Estuary.

5. Anadromous fish may be re-established in the River.

6. The diversity of benthic organisms in the Merrimack and Nashua Rivers will be considerably enhanced.

7. Diversion of wastewater to the regional plant from the Winnipesaukee-Franklin area will severely alter stream flow above Manchester and result in an associated stress on biotic life during periods of low flow.

8. Diversion of wastewater from the Nashua River drainage will increase the eutrophic condition and noxious gases emitted from that River.

9. Diversion of renovated wastewater outside the Basin would severely alter the aquatic habitats in the lower Merrimack River. Wastewater diversion from the Nashua and upper Merrimack River will cause increased water temperature and decreased dissolved oxygen during times of low flow, creating stresses on the fish population, and aquatic communities.

10. Development of property adjacent to the "clean" River will disrupt terrestrial and aquatic habitats.

11. The long run population increase would result in "natural" habitat being converted into urban development projects.

12. The seasonal tourist influx would undoubtedly be detrimental to existing "natural habitats".

13. Reduction in streamflow would adversely affect the migration of anadromous fish through the affected River segments.

14. More regionalized facilities will disturb larger areas of land and vegetation.

Hygienic

1. Treatment facilities will reduce the viruses, bacteria, and toxicants in renovated wastewater returned to the River.

2. Diversion of wastewater from the Nashua River will increase the present eutrophic and septic conditions.

3. Reduction in the numbers of bacteria will enhance the quality of agricultural crops irrigated with the River water.

Aesthetics

1. The River will have greater clarity and will be more visually appealing.

2. Odors arising from decomposition of organic matter within the Merrimack River will be reduced.

3. Withdrawals from the River for water supply will have a better taste.

4. Well landscaped treatment facilities will provide green open areas available to public access.

5. The aesthetic qualities of the Nashua River will not be improved as much.

6. Diversions from the lower River during low flow periods would result in exposure of large portions of stream bottom. Dehydration of aquatic plants attached to the stream bottom would deter from the scenic attributes of the River.

Social Opportunities

1. Reduction in the pollutant level of the Merrimack River will permit safe public access and use of the River, thus encouraging development of recreational areas and associated commercial activities.

Economic

1. Establishment of high quality recreational areas on the River will increase tourism.

2. Establishment of anadromous fish will create sport and commercial fisheries.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on the changes resulting from implementation of this scheme and the related effects these changes have on the Basin populace.

Ecologic

1. Improvement of the Merrimack River waters will enhance development of sport fishing and recreation activities.

2. Shellfish predators may become re-established in the Estuary.

3. Waterfowl and shorebirds will be encouraged to visit the Estuary with greater frequency.

4. Well landscaped and maintained treatment facility areas which are accessible to the public will provide park-like areas.

Hygienic

1. The decrease in bacteria and virus in the Merrimack River will greatly reduce the risk of infection and disease.

2. Crops irrigated with Merrimack River water will exhibit a significant reduction in numbers of bacteria.

3. Recreational activities associated with the River will be greatly enhanced.

4. Increase in seasonal and permanent population may create health and sanitary problems during periods of maximum influx.

Aesthetics

1. People will be attracted to the Basin by the scenic qualities of the River.

2. Visual and odor characteristics of the River will be improved.

3. The larger treatment facilities will provide a greater visual impact.

4. Transmission lines to the regional facilities and to the Boston area will disturb the scenic qualities of the landscape.

Social Opportunities

1. Open areas along transmission lines will provide increased habitat for wildlife.

2. Water recreational opportunities in the River Basin will be greatly improved.

3. Maximum cooperation between local and State governments will have to be attained in those areas where the water is diverted to regional plants or diverted outside the Basin.

4. Public water supply within the Basin would be reduced by diversion of water to the Boston area.

5. This scheme will decrease the flow of the Nashua River thus encouraging the existing eutrophic conditions and therefore not significantly improving recreation potential.

6. Local governments will have to cooperate extensively to justify diversion of a high quality renovated water to the Boston area.

7. Treatment facilities will provide multiple use areas available to the public.

8. The population increase during the construction phase may strain existing municipal services.

9. Beaches on the Merrimack River may be reopened.

10. Sport fishing will be greatly aided in the Estuary, the Merrimack, and Lake Winnisquam.

11. A large portion of the Merrimack River will become available for water recreation.

12. A clean Merrimack River will attract new residents, both permanent and seasonal.

13. The image and pride of River communities will be heightened by a clean attractive River.

14. Governments of River communities will have to cooperate in development, installation, and maintenance of the common treatment facility.

c. Regional Development

Regional development involves increases in a region's income, employment, economic base, environment, public health, social aspects, and aesthetic attributes of the area.

Ecologic

1. The fishery resources in the Merrimack Basin will increase substantially.

Hygienic

1. Irrigation of crops using Merrimack River water will continue with reduced health hazard.

2. Water related recreational activities on the River will increase.

3. A clean source of water will be readily accessible.

4. Diseases stemming from water recreation on the River will be greatly reduced.

Aesthetics

1. The attractiveness of the Merrimack River will be enhanced.

Social Opportunity

1. Beaches on the Merrimack can be reopened, which will encourage recreation activities.

2. Available sport fishing will increase on the Merrimack River and the Estuary.

3. Construction of each facility could create stresses on existing municipal services.

Economic

1. Recreation and related commercial enterprises will be enhanced.

2. Land values adjacent to the River will increase substantially as recreational benefits are realized and with this an increase in tax base.

3. Land values near treatment facilities and collection apparatus may decrease.

4. Land values of the River communities should increase.

5. This scheme will have a capital investment of $668 million and an annual cost of $74 million.

d. National Economic Development

National Economic Development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The fish and shellfish industries will be enhanced in the Merrimack River and Estuary.

Hygienic

1. Public health will be enhanced by a clean River.

Aesthetics

Social Opportunities

Economic

1. Tourism and recreational opportunities will be significantly encouraged.

2. The tax base of riverfront towns will improve.

3. Industry and production will benefit.

4. Diversion of water to the Boston area would provide a high quality water supply.

5. This scheme will have a capital cost of $668 million and an annual cost of $74 million.

5. SCHEME #4 - DECENTRALIZED LAND ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, and their related resources. The following points will depict specific ecologic, hygienic and aesthetic changes associated with this wastewater management scheme.

Ecologic

1. A major disturbance will occur in the terrestrial environment at the treatment sites and distribution facilities.

2. Within irrigation areas, aggravation of existing drainage conditions could result in a water saturation zone which may cause the death of some plants.

3. Depressions in overland flow sites will stay wet for longer periods resulting in possible flora changes and reduced seed germination.

4. Soil microorganism processes in the forest duff might be negated by the free chlorine contained in the applied effluent.

5. The addition of nitrogen and moisture will enhance bacterial action in the forest duff, with increased reduction of the duff.

6. Sludge disposal on the land may present significant biomagnification problems if heavy metals are not removed from the sludge.

7. The quantity and quality of wood products on the liquid and sludge disposal sites will be increased by the addition of nutrients.

8. With proper management, valuable tree species can be encouraged on the disposal sites.

9. Successional patterns in the disposal areas will be altered.

10. Pitch pines receiving wastewater may develop a shallow root system and be subject to greater degrees of windthrow damage.

11. Deer habitat can be greatly improved with transmission line clearance and open space protection.

12. Within the irrigation areas there will be an increase in the numbers of habitats of insects, especially mosquitoes.

13. Furbearers, predators, small game and most bird species will improve.

14. Wildfowl potential near the Estuary and storage lagoons will be significantly enhanced.

15. Approximately 80,000 acres will be kept essentially in their "natural" state and become available for multiple use management.

16. Approximately 14,000 acres of land will be used for lagoons.

17. The water quality in the Merrimack Basin will be greatly enhanced upon removal of the excessive nutrient load.

18. The decreased flow in the lower third of the River will cause a water temperature increase and decrease in dissolved oxygen resulting in ecological stresses for aquatic organisms.

19. The removal of pollutants and a more permanent stream flow will favorably effect species diversity and ecosystem stability throughout the River.

20. The decreased flow in the lower third of the River may hinder re-establishment of anadromous fish.

21. A more viable fishery can be established in upstream reaches.

22. Offensive odors may emanate from the various storage lagoons.

23. Treatment sites may emit offensive odors.

<u>Hygienic</u>

1. The removal of existing bacterial-viral contamination will favor a healthy environment.

2. Waterfowl feeding in the lagoons will result in a possibility of spreading pathogenic organisms found in the partially treated wastewater.

3. The shellfish beds can be harvested once the bacterial contamination in the Estuary has been removed.

4. A possible spreading of pathogenic organisms on the land by spray irrigation can increase "hygienic risks".

Aesthetics

1. The preservation of open space and "natural" tracts of land will greatly increase the scenic quality of the Basin.

2. Lagoons will be difficult to visually integrate.

3. There will be a significant visual disruption by the needed transmission lines especially in the northern part of the Basin.

The sociologic and economic factors were not evaluated in terms of environmental quality.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on these changes and their related effects on the Basin populace.

Ecologic

1. The improved river quality will enhance the sport and commercial fishing opportunities through the Basin.

2. Preserved "greenbelts" will greatly enhance the wildlife available for public enjoyment.

3. The expected tourist influx throughout the Basin will present a detriment to the "natural" habitat of the Basin.

Hygienic

1. The existing health hazard from bacterial contaminated crops in the Basin will be greatly reduced.

2. The current health hazard inherent with ingesting the River water will be eliminated

3. Most forms of water contact recreation can be re-established on the rivers of the Merrimack Basin.

Aesthetics

1. Large amounts of land will be kept in an essentially "natural" condition.

2. Open space producing needed visual amenity will be preserved.

3. Lagoon sites will require extensive land manipulation and disruption of natural conditions.

4. Visual disruption by transmission lines through the rugged terrain in the northern part of the Basin will be significant.

5. The improved quality of the water will produce a favorable visual amenity throughout the Basin.

Social Opportunities

1. Employment opportunities will increase throughout the Basin.

2. Clean water will exert a powerful effect on future land use development.

3. Irrigation techniques have the potential to reverse the declining trend of farming within the Basin.

4. There will be increased opportunity for multiple use forest management within the Basin.

5. Without proper planning land disposal could destroy the landscape.

6. A long run population increase can be expected.

7. During construction there will be a transient population influx.

8. The tourist increase will be significant given the improved recreational opportunities.

9. The agricultural and forestry potential might be able to hold the line against the population decrease in rural areas.

10. Basin communities will be able to make more uniform decisions with regard to the direction of future growth.

11. The water supply quality and quantity will be markedly higher.

12. Increases in population because of the improved quality of the River will place greater demands on existing systems of education, protection (fire and police) and utilities.

13. All forms of public recreation, both land and water, will be significantly enhanced.

14. The Basin communities will take pride in and identify with a clean River.

15. There will be a definite increase in readily accessible clean water to the urban communities of the Basin.

16. Land disposal sites will be looked at with pride or become a thing to hide dependent on proper planning.

17. A considerable amount of cooperation between the various states and communities will be necessary to implement this scheme.

Economic

1. Property values along the River will increase, those next to the treatment sites may decrease.

2. A significant increase in the overall tax base within the Basin will occur.

3. The increased wildlife potential will attract a large tourist industry.

4. An improved fishery will attract significant numbers of sportsmen.

c. Regional Development

Regional development involves increases in a region's income, employment, economic base, environment, and social well-being.

Ecologic

1. Increased wildlife potential will attract varied sportsmen.

Hygienic

1. The removal of water-borne pathogens will significantly reduce the "hygienic risk" inherent with ingesting the water or water contact recreation.

Aesthetics

1. The water quality, the land and the related natural resources will all be enhanced providing a more enjoyable Basin in which to live.

Social Opportunities

1. Various industries will be attracted to the Basin because of increased availability of high quality water.

2. A population increase throughout the Basin can be expected.

3. Services, transportation, construction, and employment will face short-run demands during construction.

4. Termination of construction of treatment facilities could produce repercussions and dislocations.

5. Down trends in agricultural and forest production within the Basin can be reversed.

6. Long run employment could increase since the Basin will become a more enjoyable region in which to live and work.

Economic

1. This scheme has an initial capital investment of $1108 million with an annual operating and maintenance cost of $88 million.

2. The increased timber production within the disposal areas could start a significant new approach to the industry.

3. The utilization of wastewater as a valuable resource in crop production will be realized.

4. A maximum annual agricultural benefit of about $6.7 million could be realized with this scheme.

5. A significant tourist increase will contribute definite economic benefits to the various communities of the Basin.

d. National Economic Development

National Economic Development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The Merrimack River could become an example to emulate in terms of national environmental policy.

Economic

1. Significant precedents in national economic policy could be set.
2. Significant industrial attractions will be presented given higher water quality.
3. A long run population increase with concurrent increase in employment can be expected.
4. The tourist industry will likely increase significantly.
5. Agricultural and forest management trends may receive new significance.
6. A maximum annual agricultural benefit of about $6.7 million could be realized with this scheme.
7. This scheme will cost $1108 million to construct with an annual cost of $88 million.
8. Increased timber production within the disposal areas could start a significant new approach to the industry.
9. The utilization of wastewater as a valuable resource in crop production will be realized.

The hygienic, aesthetic and social opportunities were not evaluated in terms of National Economic Development.

6. SCHEME #5 - DECENTRALIZED WATER AND LAND ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, and their related resources. The following points will depict specific ecologic, hygienic and aesthetic changes associated with this wastewater management scheme.

Ecologic

1. A major disturbance will occur in the terrestrial environment at the treatment sites and distribution facilities.
2. Within irrigation areas, aggravation of existing drainage conditions could result in a water saturation zone which may cause the death of some plants.
3. Depressions in overland flow sites will stay wet for longer periods resulting in possible flora changes and reduced seed germination.
4. Soil microorganism processes in the forest duff might be negated if excessive chlorine is contained within the effluent.
5. The addition of nitrogen and moisture will enhance bacterial action within the forest duff.
6. Sludge disposal on the land may present significant biomagnification problems in the flood chain if heavy metals are not removed from the sludge.
7. The quantity and quality of wood products on the disposal sites will be increased by the addition of nutrients.
8. With proper management valuable tree species can be encouraged on the disposal sites.
9. Successional patterns within the disposal areas will be altered.
10. If wastewater is applied to stands of pitch pine, they may develop a shallow root system and be subject to greater degrees of windthrow damage.

11. Deer habitat can be greatly improved with transmission line clearance and open space protection.

12. Within irrigation areas, there will be an increase in the number of insects, especially mosquitoes.

13. The habitats of furbearers, predators, small game and m bird species will improve.

14. Wildfowl potential near the Estuary and storage lagoons will be significantly enhanced.

15. Approximately 27,000 acres will be kept essentially in their "natural" state and be available for multiple use management.

16. Approximately 5,000 acres of land will be utilized for lagoons.

17. The water quality in the Merrimack Basin will be greatly enhanced upon removal of the excessive nutrient load.

18. Increased water quality will make the re-establishment of an anadromous fishery possible.

19. The removal of pollutants and a more permanent stream flow will favorably affect species diversity and ecosystem stability throughout the River.

20. The widespread arrangement of returning renovated wastewater to the River avoids either localized or general alteration of water volume.

21. A more viable fishery can be established in upstream reaches.

22. Offensive odors can emanate from the various storage lagoons.

23. Treatment sites may emit offensive odors.

Hygienic

1. The removal of existing bacterial-viral contamination will favor a healthy environment.

2. The shellfish beds can be harvested once the bacterial contamination in the Estuary has been removed.

3. A possible spreading of pathogenic organisms on the land by spray irrigation can increase "hygienic risks".

Aesthetics

1. The preservation of open space and "natural" tracts of land will greatly increase the scenic quality of the Basin.

2. Lagoons will be difficult to visually integrate.

3. There will be a significant visual disruption by the needed transmission lines especially in the northern part of the Basin.

The sociologic and economic factors were not evaluated in terms of environmental quality.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on these changes and their related effects on the Basin.

Ecologic

1. The improved River quality will enhance the sport and commercial fishing opportunities throughout the Basin.

2. Preserved "greenbelts" will greatly enhance the wildlife available for public enjoyment.

3. The expected tourist influx throughout the Basin will present a detriment to the "natural" habitat of the Basin.

Hygienic

1. The existing health hazard from bacterially contaminated crops in the Basin will be greatly reduced.

2. The current health hazard inherent with ingesting the River water will be eliminated.

3. Water-contact recreation can be re-established on the rivers of the Merrimack Basin.

Aesthetics

1. Large amounts of land will be kept in an essentially natural condition.

2. Open space producing needed visual amenity will be preserved.

3. Lagoon sites will require extensive land manipulation and disruption of natural conditions.

4. Visual disruption by transmission lines through the rugged terrain in the northern part of the Basin will be significant.

5. The improved quality of the water will produce definite favorable visual amenity throughout the Basin.

Social Opportunities

1. Employment opportunities will increase throughout the Basin.

2. Clean water will exert a powerful effect on future land use development.

3. Irrigation techniques have the potential to reverse the declining trend of farming within the Basin.

4. There will be increased opportunity for multiple use forest management within the Basin.

5. Without proper planning land disposal could destroy the landscape.

6. A long run population increase can be expected.

7. During construction there will be a transient population influx.

8. The tourist increase will be significant given the improved recreational opportunities.

9. The agricultural and forestry potential might be able to hold the line against the population decrease in rural areas.

10. Basin communities will be able to make more uniform decisions with regard to future growth.

11. The water supply quality and quantity will be markedly higher.

12. With increases in population due to clean water greater demands will be made on existing systems of education, protection (fire and police), and utilities.

13. All forms of public recreation, both land and water, will be significantly enhanced.

14. The Basin communities will take pride in and identify with a clean river.

15. There will be a definite increase of clean water of ready access to the urban communities of the Basin.

16. Land disposal sites will be looked at with pride or become a thing to hide dependent on proper planning.

17. A lesser degree of institutional complexity will be called for on the interstate level but still complete inter-community cooperation will be required.

<u>Economic</u>

1. Property values along the River will increase; those next to the treatment sites may decrease.

2. A significant increase in the overall tax base within the Basin will occur.

3. The increased wildlife potential will attract a large tourist industry.

4. An improved fishery will attract significant numbers of sportsmen.

c. Regional Development

Regional development involves increased in a region's income, employment and overall improvement of their economic base, environment, and social well-being.

<u>Economic</u>

1. Increased wildlife potential will attract varied sportsmen.

<u>Hygienic</u>

1. The removal of water-borne pathogens will significantly reduce the "hygienic risk" inherent with ingesting the water or water-contact recreation.

Aesthetics

1. The water quality, the land and the related natural resources will all be enhanced providing a more enjoyable Basin in which to live.

Social Opportunities

1. Various industries will be attracted to the Basin due to increased availability of high quality water.

2. A population increase throughout the Basin can be expected.

3. Services, transportation, construction, and employment will face short-run demands during construction.

4. Termination of construction of treatment facilities could produce repercussions and dislocations.

5. Down trends in agriculture and forest production within the Basin can be reversed.

6. Long run employment could increase since the Basin will become a more enjoyable region in which to live and work.

Economic

1. This scheme has an initial capital investment of $958 million with an annual cost of $94 million.

2. Increased timber production within the disposal areas could start a significant new approach to the industry.

3. Utilization of wastewater as a valuable resource in crop production will be realized.

4. A maximum annual agricultural benefit of about $2.5 million could be realized with this scheme.

5. A significant tourist increase will contribute definite economic benefits to the various communities of the Basin.

6. Various industries will be attracted due to increased availability of high quality water.

d. National Economic Development

National Economic Development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The Merrimack River could become an example to emulate in terms of national environmental policy.

Economic

1. Significant precedents in national economic policy could be set.
2. Significant industrial attractions will be presented given higher water quality.
3. A population increase with concurrent increase in employment can be expected.
4. The tourist industry will likely increase significantly.
5. Agricultural and forest management trends may receive new significance.
6. A maximum annual agricultural benefit of about $2.5 million could be realized with this scheme.
7. This scheme will cost $958 million to construct with an annual cost of $94 million.
8. Increased timber production within the disposal areas could start a significant new approach to the industry.
9. Utilization of wastewater as a valuable resource in crop production will be realized.

The hygienic, aesthetic and social opportunities were not evaluated in terms of National Economic Development.

7. SCHEME #6 - DECENTRALIZED, ALTERNATING WATER AND LAND ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, and their related resources. The following points will depict specific ecologic, hygienic and aesthetic changes associated with this wastewater management scheme.

Ecologic

1. A major disturbance will occur in the terrestrial environment at the treatment sites and distribution facilities.
2. Within irrigation areas, aggravation of existing drainage conditions could result in a water saturation zone which may cause the death of some plants.
3. Depressions in overland flow sites will stay wet for longer periods resulting in possible flora changes and reduced seed germination ratios.
4. Soil microorganism processes in the forest duff might be negated if the effluent discharges contain excessive chlorine residuals.
5. The addition of nitrogen and moisture will enhance bacterial action within the forest duff with increased reduction of the duff.
6. Sludge disposal on the land may present significant biomagnification problems within the food chains of the Basin if heavy metals are not controlled in the sludge.
7. The quantity and quality of wood products on the disposal sites will be increased by the addition of nutrients.
8. With proper management valuable tree species can be encouraged on the disposal sites.
9. Successional patterns within the disposal areas will be altered.
10. If wastewater is applied to pitch pine stands, they may develop a shallow root system and be subject to greater degrees of windthrow damage.

11. Deer habitat can be greatly improved with transmission line clearance and open space protection.

12. Within the irrigation areas there will be an increase in the number of insects, especially mosquitoes.

13. Habitats of furbearers, predators, small game and most bird species will improve.

14. Wildfowl potential near the Estuary will be significantly enhanced.

15. Approximately 25,000 acres will be kept essentially in their "natural" state and available for multiple use management.

16. Approximately 630 acres of land will be utilized for lagoons.

17. Water quality in the Merrimack Basin will be greatly enhanced upon removal of the excessive nutrient load.

18. Widespread arrangement of returning renovated wastewater to the river avoids either localized or general alteration of water volume.

19. Removal of pollutants and a more permanent stream flow will favorably affect species diversity and ecosystem stability throughout the River.

20. Increased water quality will make the re-establishment of an anadromous fishery possible.

21. A viable fishery can be established in upstream reaches.

22. Treatment sites may emit offensive odors.

<u>Hygienic</u>

1. The removal of existing bacterial-viral contamination will favor a healthy environment.

2. Shellfish beds can be harvested once the bacterial contamination has been removed.

3. A possible spreading of pathogenic organisms on the land by spray irrigation can increase "hygienic risks".

Aesthetics

1. The preservation of open space and "natural" tracts of land will greatly increase the scenic quality of the Basin.

2. Lagoons will be difficult to visually integrate.

3. There will be a significant visual disruption by the needed transmission lines especially in the northern part of the Basin.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on these changes and their related effects on the Basin populace.

Ecologic

1. The improved river quality will enhance the sport and commercial fishing opportunities throughout the Basin.

2. Preserved "greenbelts" will greatly enhance the wildlife available for public enjoyment.

3. The expected tourist influx throughout the Basin will present a detriment to the "natural" habitat of the Basin.

Hygienic

1. The existing health hazard from bacterialy contaminated crops in the Basin will be greatly reduced.

2. The current health hazard inherent with ingesting the River water will be eliminated.

3. Water-contact recreation can be re-established on the rivers of the Merrimack Basin.

Aesthetics

1. Large amounts of land will be kept in an essentially "natural" condition.

2. Open space producing needed visual amenity will be preserved.

3. Lagoon sites will require extensive land manipulation and disruption of natural conditions.

4. Visual disruption by transmission lines through the rugged terrain in the northern part of the Basin will be significant.

5. The improved quality of the water will produce favorable visual amenity throughout the Basin.

Social Opportunities

1. Employment opportunities will increase throughout the Basin.

2. Clean water will exert a powerful effect on future land use development.

3. Irrigation techniques have the potential to reverse the declining trend of farming within the Basin.

4. There will be increased opportunity for multiple use forest management within the Basin.

5. Without proper planning land disposal could destroy the landscape.

6. A population increase can be expected.

7. During construction there will be a transient population influx.

8. The tourist increase will be significant given the improved recreational opportunities.

9. The agricultural and forestry potential might be able to hold the line against the population decrease in rural areas.

10. Basin communities will be able to make more uniform decisions with regard to the direction of future growth.

11. The water supply quality and quantity will be markedly higher.

12. With increases in population due to clean water, greater demands will be made on existing systems of education, protection (fire and police) and utilities.

13. All forms of public recreation, both land and water, will be significantly enhanced.

14. The Basin communities will take pride in and identify with a clean River.

15. There will be a definite increase of clean water of ready access to the urban communities of the Basin.

16. Land disposal sites will be looked at with pride or become a thing to hide dependent on proper planning.

17. A considerable amount of cooperation between the various states and communities will be necessary to implement this scheme.

Economic

1. Property values along the River will increase; those next to the treatment sites may decrease.

2. A significant increase in the overall tax base within the Basin will occur.

3. The increased wildlife potential will attract a large tourist industry.

4. An improved fishery will attract significant numbers of sportsmen.

c. Regional Development

Regional development involves increases in a region's income, employment, economic base, environment, and social well-being.

Ecologic

1. Increased wildlife potential will attract varied sportsmen.

Hygienic

1. The removal of water-borne pathogens will significantly reduce the "hygienic risk" inherent with ingesting the water or water-contact recreation.

Aesthetics

1. The water quality, the land and the related natural resources will all be enhanced providing a more enjoyable Basin in which to live.

Social Opportunities

1. Various industries will be attracted to the Basin due to increased availability of high quality water.

2. A population increase throughout the Basin can be expected.

3. Services, transportation, construction, and employment will face short-run demands during construction.

4. Termination of construction of treatment facilities can produce repercussions and dislocations.

5. Down trends in agricultural and forest production within the Basin can be reversed.

6. Long run employment could increase since the Basin will become a more enjoyable region in which to live and work.

Economic

1. This scheme has an initial capital investment of $996 million with an annual cost of $96 million.

2. The increased timber production within the disposal areas could start a significant new approach to the industry.

3. The utilization of wastewater as a valuable resource in crop production will be realized.

4. A maximum annual agricultural benefit of about $1.2 million could be realized with this scheme.

5. A significant tourist increase will contribute definite economic benefits to the various communities of the Basin.

d. National Economic Development

National Economic Development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The Merrimack River could become an example to emulate in terms of national environmental policy.

Economic

1. Significant precedents in national economic policy could be set.

2. Significant industrial attractions will be presented given higher water quality.

3. A population increase with concurrent increase in employment can be expected.

4. The tourist industry will likely increase significantly.

5. Agricultural and forest management trends may receive new significance.

6. A maximum annual agricultural benefit or about $1.2 million be realized with this scheme.

7. This scheme will cost $996 million to construct with an annual cost of $96 million.

8. Increased timber production within the disposal areas could start a significant new approach to the industry.

9. Utilization of wastewater as a valuable resource in crop production will be realized.

The hygienic, aesthetic and social opportunities were not evaluated in terms of National Economic Development.

8. SCHEME #7 - CENTRALIZED, ALTERNATING WATER AND LAND ORIENTED SYSTEM

a. Environmental Quality

Environmental quality implies the preservation or enhancement of the water, the land, and their related resources. The following points will depict specific ecologic, hygienic and aesthetic changes associated with this wastewater management scheme.

Ecologic

1. A major disturbance will occur in the terrestrial environment at the treatment sites and distribution facilities.
2. Within irrigation areas, there may be aggravation of existing drainage conditions resulting in a water saturation zone which may cause the death of some plants.
3. Depressions in overland flow sites will stay wet for longer periods resulting in possible flora changes and reduced seed germination ratios.
4. Soil microorganism processes in the forest duff might be negated if the effluent discharges contain excessive chlorine residuals.
5. The addition of nitrogen and moisture will enhance bacterial action in the forest duff.
6. Sludge disposal on the land may present significant biomagnification problems in the food chain if heavy metals are not controlled in the sludge.
7. The quantity and quality of wood products on the liquid sludge disposal sites will be increased by the addition of nutrients.
8. With proper management, valuable tree species can be encouraged on the disposal sites.
9. Successional patterns within the disposal areas will be altered.
10. If wastewater is applied to pitch pine, this species may develop a shallow root system and be subject to greater degrees of windthrow damage.

11. Deer habitat can be greatly improved with transmission line clearance and open space protection.

12. Within the irrigation areas there will be an increase in the number of insects, especially mosquitoes.

13. Habitats of furbearers, predators, small game and most bird species will improve.

14. Wildfowl potential near the Estuary will be significantly enhanced.

15. Approximately 38,000 acres will be kept essentially in their "natural" state and remain available for multiple use management.

16. Approximately 1,000 acres of land will be utilized for lagoons.

17. The water quality in the Merrimack Basin will be greatly enhanced upon removal of the excessive nutrient load.

18. The removal of pollutants and a more permanent stream flow will favorably affect species diversity and ecosystem stability throughout the Basin.

19. Increased water quality will make the re-establishment of an anadromous fishery possible.

20. A more viable fishery can be established in upstream reaches.

21. Incineration of sludge may produce significant odor and particulate matter problems within the adjacent area.

22. Treatment sites may emit offensive odors.

<u>Hygienic</u>

1. The removal of existing bacterial-viral contamination will favor a healthy environment.

2. The shellfish beds can be harvested once the bacterial contamination has been removed.

3. A possible spreading of pathogenic organisms on the land by spray irrigation can increase "hygienic risks".

Aesthetics

1. The preservation of open space and "natural" tracts of land will greatly increase the scenic quality of the Basin.

2. Lagoons will be difficult to visually integrate.

3. There will be significant visual disruption by the needed transmission lines.

The sociologic and economic factors were not evaluated in terms of environmental quality.

b. Social Well-Being

Social well-being implies how the people will be affected in terms of their health, amenities, etc. The following points will focus on these changes and their related effects on the Basin populace.

Ecologic

1. The improved river quality will enhance the sport and commercial fishing opportunities throughout the Basin.

2. Preserved "greenbelts" will greatly enhance the wildlife available for public enjoyment.

3. The expected tourist influx throughout the Basin will present a detriment to the "natural" habitat of the Basin.

Hygienic

1. The existing health hazard from bacterialy contaminated crops in the Basin will be greatly reduced.

2. The current health hazard inherent with ingesting the river water will be eliminated.

3. Most forms of water-contact recreation can be re-established on the rivers of the Merrimack Basin.

Aesthetics

1. Large amounts of land will be kept in an essentially "natural" condition.

2. Open space producing needed visual amenity will be preserved.

3. Lagoon sites will require extensive land manipulation and disruption of natural conditions.

4. Visual disruption by transmission lines through the rugged terrain in the northern part of the Basin will be significant.

5. The improved quality of the water will produce a favorable visual amenity throughout the Basin.

Social Opportunities

1. Employment opportunities will increase throughout the Basin.

2. Clean water will exert a powerful effect on future land use development.

3. Irrigation techniques have the potential to reverse the declining trend of farming within the Basin.

4. There will be increased opportunity for multiple use forest management within the Basin.

5. Without proper planning, land disposal could destroy the landscape.

6. A long run population increase can be expected.

7. During construction there will be a transient population influx.

8. The tourist increase will be significant given the improved recreational opportunities.

9. The agricultural and forestry potential might be able to hold the line against the population decrease in rural areas.

10. There will be more time for more uniform decision making by Basin communities with regard to direction of future growth.

11. The water supply quality and quantity will be markedly higher.

12. With increase in population due to clean water, greater demands will be made on existing systems of education, protection (fire and police), and utilities.

13. All forms of public recreation, both land and water, will be significantly enhanced.

14. The Basin communities will take pride in and identify with a clean river.

15. There will be a definite increase of clean water of ready access to the urban communities of the Basin.

16. Land disposal sites will be looked at with pride or become a thing to hide dependent on proper planning.

17. A considerable amount of cooperation between the various states and communities will be necessary to implement the scheme.

Economic

1. Property values along the River will increase, those next to the treatment sites may decrease.

2. A significant increase in the overall tax base within the Basin will occur.

3. The increased wildlife potential will attract a large tourist industry.

4. An improved fishery will attract significant numbers of sportsmen.

c. Regional Development

Regional development involves increases in a region's income, employment, economic base, environment, and social well-being.

Ecologic

1. There is a potential for increased wildlife.

Hygienic

1. The removal of water-borne pathogens will significantly reduce the "hygienic risk" inherent with ingesting the water or water-contact recreation.

Aesthetics

1. The water quality, the land and the related natural resources will all be enhanced providing a more enjoyable Basin in which to live.

Social Opportunities

1. Various industries will be attracted to the Basin due to increased availability of high quality water.

2. A population increase throughout the Basin can be expected.

3. Services, transportation, construction, and employment will face short-run demands during construction.

4. Termination of construction of treatment facilities could produce repercussions and dislocations.

5. Down trends in agricultural and forest production within the Basin can be reversed.

6. Long run employment could increase since the Basin will become a more enjoyable region in which to live and work.

Economic

1. This scheme has an initial capital investment of $843 million with an annual cost of $78 million.

2. The increased timber production within the disposal areas could start a significant new approach to the industry.

3. The utilization of wastewater as a valuable resource in crop production will be realized.

4. A maximum annual agricultural benefit of about $3.3 million could be realized with this scheme.

5. A significant tourist increase will contribute definite economic benefits to the various communities of the Basin.

d. National Economic Development

National Economic Development involves increasing the value of the Nation's goods and services and improving national economic efficiency.

Ecologic

1. The Merrimack River could become an example to emulate in terms of national environmental policy.

Economic

1. Significant precedents in national economic policy could be set.

2. Significant industrial attractions will be presented given higher water quality.

3. A long run population increase with concurrent increase in employment can be expected.

4. The tourist industry will likely increase significantly.

5. Agricultural and forest management trends may receive new significance.

6. A maximum annual agricultural benefit of about $3.3 million could be realized with this scheme.

7. This scheme will cost $843 million to construct with an annual cost of $78 million.

8. Increased timber production within the disposal areas could start a significant new approach to the industry.

9. The utilization of wastewater as a valuable resource in crop production will be realized.

The hygienic, aesthetic, and social opportunities were not evaluated in terms of National Economic Development.